The fish resources of the northwest Pacific

FAO FISHERIES TECHNICAL PAPER

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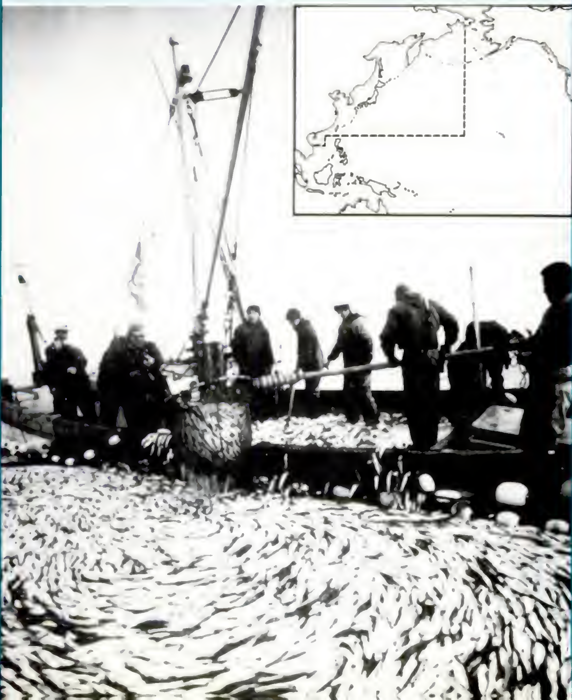

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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by
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PREPARATION OF THIS PAPER

This document has been prepared as part of FAO's Regular Programme activities aimed first at reviewing the resources and fisheries in the region where the world's highest production has been achieved in recent years and second at assisting the scientists and administrators in the world, providing a case study on a productive region, for further consideration on better research and management of the fisheries resources in each of the specific waters in the future.

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ABSTRACT

Fish resources in the region, including finfish, cephalopods, prawns and shrimps have been reviewed in conjunction with the historical change in the fisheries on them. The description of the environmental conditions and their relationships with these resources have also been made. The assessment of important stocks has been made in connection with both the natural and man-made causes. Changes in the dominance in the coastal pelagic fish community have also been discussed. The potential yield has been estimated for major species, species groups and total harvest. Recommendations on future research and management have been made based on the findings obtained through this study.

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SUMMARY

In this paper the environmental conditions, major fisheries resources and their state of exploitation in the Northwest Pacific, defined as FAO Fishing Area 61, have been reviewed. The description of the environment covers a fairly wide field including topography, hydrography, plankton, primary production and benthos. The review of resources and fisheries is also fairly comprehensive covering all of the major species groups such as salmon, demersal fish, coastal pelagic fish, tunas and billfishes, cephalopods, prawns and shrimps. Important stocks have been assessed in further detail by species in each of the species groups; in terms of quantity of production, commercial value and biological/ecological concepts.

An overall discussion of the biologically important features of these resources and the distinctive natures of these stocks and fish communities in this particular area have been carried out. This includes a substantial discussion of the changes in the abundance and dominancy in coastal pelagic fish stocks around Japan.

The total potential yield has, on the basis of the above review, been estimated by major species group.

The results obtained are summarized as follows:

1. The Northwest Pacific is characterized by its environmental complexities. There is a vast extent of continental shelves in some parts of the area. In other parts, there are narrow shelf-areas, but with highly favourable oceanographic conditions, provided by both the cold and warm sea currents. The former regions are typically shown along the eastern Siberian coast, in the Okhotsk Sea, Yellow Sea, East China Sea and northwestern South China Sea while the latter occur along the Kuril Islands, around Japan and the Ryukyu/Nansei Shoto archipelago. The oceanic zone in the area is also productive for oceanic resources being supported by the favourable oceanographic conditions provided by the complex of several major sea currents. Thus the area exhibits various climatic conditions for both demersal and pelagic resources, namely boreal, temperate and sub-tropical environments.

2. Under this advantageous environment, the total production from the Northwest Pacific is the highest out of the various world fishing areas with about 18-20 million tons of annual catch. The production is also distinct, under the above mentioned complexity, in its well-balanced composition between demersal and pelagic fish components which quite resembles that of the second highest productive area, Northeast Atlantic (FAO Fishing Area 27) where about 12 million tons of annual catch is being achieved.

3. Salmon stocks in the northern region, which were once depleted by overfishing and deterioration in their spawning/nursery rivers, have shown distinct signs of a recovery of stock abundance. A remarkable increase in the return of chum salmon of Japanese origin in recent years, which has resulted from the success in the re-stocking programme, is *inter alia* encouraging. A substantial increase in the total salmon catch is therefore expected in the near future.

4. Almost all the conventional demersal fish stocks in the area have been fully exploited and the exploitable fishing grounds for bottom gears in the area have been almost entirely exploited. The stocks can be categorized into two kinds, one of which though fully or nearly fully exploited has been maintained at a high (or a certain) level of abundance. The other group has been seriously depleted. The former includes Alaska pollack and Pacific cod in the Okhotsk Sea and northern region, Atka mackerel in the northern region, sandlances in the entire area, many demersal stocks around Japan, largehead hairtail and filefish in the Yellow Sea and East China Sea. The latter includes rockfishes in the northern region, yellowfin sole in the Okhotsk Sea, red seabream around Japan and many demersal fish of commercial value in the Yellow Sea and East China Sea.

5. The continuous high production of Alaska pollack with about 3-3.5 million tons of annual catch is a highlight among demersal stocks in the area, and this has provided the largest single demersal species fish catch in the world. However, the catch seems to have reached its maximum level, and no further increase is expected.

6. The serious depletion of many demersal stocks in the Yellow Sea and East China Sea is, by contrast, another distinctive feature. The stock abundance of many commercially important species has been depleted during the 1960's to about 1/5th to 1/10th of their previous level. This was mostly due to overfishing. No positive sign of recovery has been observed so far, though several strict regulatory measures have been imposed on the offshore fishing. Greater catches would be achieved if a suitable management scheme, covering the entire distribution range and life history of these stocks, were to be applied.

7. Coastal pelagic fish stocks in the Northwest Pacific have shown various distinctive features. These are firstly, the very high level of productivity with 3-6 million tons of annual catches, secondly, the large fluctuations in the abundance of many species and thirdly, a dramatic change in dominancy from one species to another. These features are most distinguishable in the stocks around Japan and involve Pacific herring, Pacific saury, Japanese sardine, Japanese chub mackerel, Japanese anchovy, and Japanese Jack mackerel. These have shown kaleidoscopic changes in the dominancy in the pelagic fish community there.

8. There have been dramatic changes in the stock abundance of Japanese sardine. The catch, which had once been reduced to about 9,000 tons around the mid-1960's, now exceeds 3.6 million tons and is currently the world's largest single species catch.

9. Clear explanations for these changes have not been given so far. However, it has been generally accepted that the major causes are probably natural and that a direct link with the effects of fishing may be very weak. Further research and a study of all of the possible and probable causes are required in the future.

10. The total pelagic fish catch around Japan for all species combined had been fairly stable at about 2 million tons for a number of years apart from the above mentioned change in species composition until the early 1970's when the Japanese sardine burst. This suggests that there might be a ceiling for the total productivity of these fish determined by (1) area, (2) availability of food items, and (3) species composition. The far greater catches in recent years with 4-5 million tons may not be stable.

11. Tunas and billfishes, including those distributed beyond the Northwest Pacific which form the same stocks, generally appear to have been fully exploited. The only exception is for smaller tunas such as bullet and frigate tunas in the southern region. A far greater catch therefore cannot be expected.

12. Cephalopods with the exception of Japanese flying squid and other cephalopod stocks around Japan may constitute the only resources in the area which still retain ample potential for future expansion. The oceanic squids in the northern region together with coastal cephalopods in the southern region could provide a substantially large increase in catch.

13. Prawn and shrimp stocks in the area have been generally fully and partly overexploited. A greater catch is therefore not expected.

14. Total potential yield has been estimated by species group to be (in '000 t); salmon: 300-350, demersal fish: 6,500-7,000, coastal pelagic fish: 5,800-6,500, tunas and billfishes: 280-380, cephalopods: 950-1,250, prawns and shrimps: 400-600, other fish (current level): 3,800, others (current level): 1 750, totalling 19,780-21,630. The potential for increase is about 0.6-0.9 million tons, showing that about 92-96 percent of the total potential yield has already been realized by current fishing.

15. Recommendations on the resources management and research to be employed in the future have been made on both the technical aspects and the institutional arrangements.

16. It is specifically noted that information on the resources and the fisheries on them is extremely scant in the southern region and in the northwestern Japan Sea. Further intensified research and documentation in this area is urgently awaited.

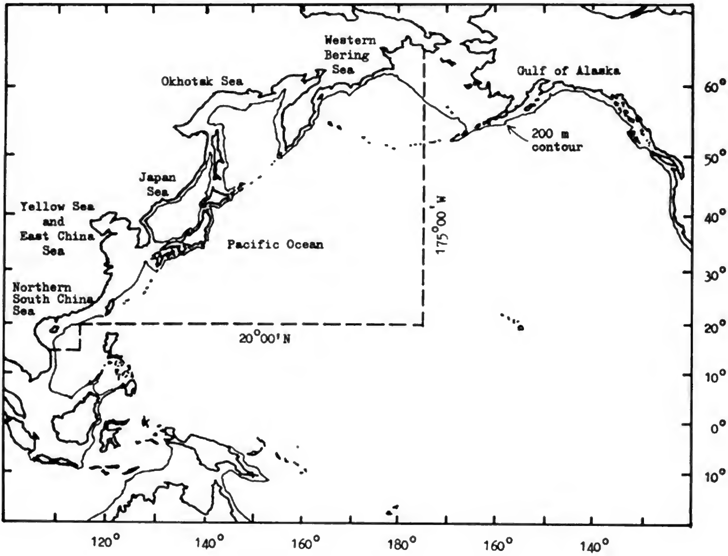

Figure 1. Definition of the area, Northwest Pacific (FAO Fishing Area 61), and the extent of the continental shelf area shallower than 200 m. See Table 1 for the areas of sea and continental shelf.

1. TOPOGRAPHY

The Northwest Pacific as defined here is the area bordered by the Asian and Siberian coasts, north of 20°N and west of 175°W, which includes a small part of the waters south of 20°N along the Asian coast bordered north of 15°N and west of 115°N. It is divided by archipelagos and peninsulas into a number of semi-enclosed seas: Western Bering Sea, Okhotsk Sea, Japan Sea, Yellow Sea and East China Sea. It also includes the northwestern tip of the South China Sea, as well as a large part of the open sea of the Northwest Pacific Ocean.

1.1 Western Bering Sea

The eastern border line of the area (175°W) divides the Bering Sea into two. The western part, included in the present area, mostly comprises the deep Aleutian Basin and has only a narrow continental shelf area along the Siberian coast and the Aleutian Islands. The main area of the continental shelf in the Bering Sea lies in the eastern half, and is discussed in another paper on the Northeast Pacific. The sea area and continental shelf area (shallower than 200 m) in the western Bering Sea are estimated to be about 1,340,000 km^2 and 320,000 km^2 respectively.

1.2 Okhotsk Sea

The abyssal zone is limited to the southern half of the Okhotsk Sea and consists of a deep basin, which is called the Okhotsk Abyssal Plain, and which runs along the northern coasts of the Kuril Islands. The continental shelf is well developed along the coasts of the West Kamchatka, Okhotsk District and Sakhalin. The sea and continental shelf area extend to about 1,590,000 km^2 and 620,000 km^2 respectively.

1.3 Japan Sea

The Japan Sea is separated from the adjacent seas by four narrow straits (Tatar, Soya, Tsugaru and Kanmon Straits) and one relatively wide strait (Korea Strait). All the straits are very shallow, not deeper than 130 m, while the straits between other seas and the Pacific Ocean are generally deep. The Japan Sea has a narrow continental shelf along the coasts (250,000 km^2) and the abyssal zone deeper than 1,000 m comprises a large part (61 percent) of its entire area of about 978,000 km^2.

A small seamount range runs from south to north along the Japanese coast and a few rises are located in the southern and western parts of the abyssal basin. They accompany a number of "Guyot" type (seamount with flat summit) shallow rises.

1.4 Pacific Ocean

In the Northwest Pacific a number of the deepest trenches in the world are located. At the northernmost, the Aleutian Trench runs along the south of the Aleutian Islands. The trench extends from off the Komandorsky Islands in the west, to the Gulf of Alaska in the east beyond the eastern border of the area. It is 3,700 km long with a deepest depth of 7,822 m. From offshore of southeast Kamchatka, which is close to the western tip of the Aleutian Trench, the Kuril-Kamchatka Trench runs southwestwards along the Kamchatka Peninsuia and Kuril Islands. This trench, which is 2,200 km long extends to the south of Hokkaido and has a deepest depth of 10,542 m. The Japan Trench runs along the northern coast of Japan without disruption from the Kuril-Kamchatka Trench. It extends to offshore of the Izu Peninsula, and is 800 km long with a deepest depth of 8,412 m. At the southwestern end is a trench, now called the Izu-Bonin Trench, which extends towards the Mariana Trench and is 800 km long with a deepest depth of 9,810 m. The Mariana Trench extends further south beyond the southern border of the area (20°N) to about 10°N. It is 2,250 km long and has a deepest depth of 11,034 m which is the deepest on record in the world. Another trench, the Ryukyu/Nansei-shoto Trench lies outside the Ryukyu Islands. It extends from the south of Kyushu to the east of Taiwan and is 2,250 km long with a deepest depth of 7,507 m. These trenches are generally very narrow, with average widths of about 50-90 km. Exceptions are the Kuril-Kamchatka and the Japan Trenches for which the average width ranges from 100-120 km.

There are six major submarine ridges in the Northwest Pacific. The South Honshu Ridge runs along the west of the Izu-Bonin (Ogsawara) and Mariana Trenches from the south of the Izu Peninsula down to about 12°N with many volcanic summits rising above the water. The Ryukyu Ridge runs along the Ryukyu Islands from the southern tip of the Kyushu. It reaches Taiwan and further extends to the northern tip of the Philippines. Another ridge, the Kyushu-Palau Ridge runs southward from the south of Kyushu and reaches Palau Island (8°N) beyond the southern border of the area. The

Northwest Seamounts Range (Emperor Seamounts) runs slightly easterly southward from the south of the Komandorsky Islands to about 30°N and 175°E. This is characterized by no visible summits above the sea surface, but many submerged seamounts including a number of "Guyot"-type seamounts with very flat summits - especially in the southern part of the Range. Some of these guyots are shallow, 70-400 m deep and form fairly large flat summits, 30-80 km in diameter. From the southern tip of the Range, the Hawaiian Ridge runs in a southeasterly direction to Hawaii Island (155°W) beyond the eastern border of the area. A few guyots are also located on the northwestern part of the Ridge, around Midway Island, which falls in the present area. The westernmost part of the Marcus-Neker Rise, which runs westward from the central part of the Hawaiian Ridge slightly south of the 20°N, emerges into the area at around 20°N and 160°E, and extends towards Marcus Island. The Rise also accompanies many submerged seamounts and guyots but most of these are deeper with rough summits. The continental shelves are quite narrow along the Pacific coasts of Kamchatka, Kuril Islands, Japanese mainland and Ryukyu Islands - with an estimated area of about 160,000 km^2. These constitute the smallest among the six sea regions in the area.

1.5 Yellow Sea and East China Sea

The entire Yellow Sea and a fairly large portion of the East China Sea are comprised of shallow areas of continental shelf with an area estimated to be about 940,000 km^2. This is the largest shelf area among the regions in the area and accounts for about 80 percent of the sea area which is about 1,169,000 km^2.

With the exception of a narrow abyssal basin along the inside of the Ryukyu Islands and numerous small islands in the shallow area along the entire coast, the topography in this region is rather flat.

1.6 Northwestern South China Sea

The Formosa Strait and the southern Chinese coast including the Gulf of Tonkin bordered by the Vietnamese coast in the west, also includes a large proportion of shelf area which is estimated to be about 480,000 km^2. The deeper part of the region is mostly composed of plain continental slopes apart from a few islands and rises in the south of Taiwan, Province of China.

The sea-area and continental shelf in each region are summarized in Table 1.

Table 1

Areas of sea and continental shelf, shallower than 200 m in the Northwest Pacific.1/

(1,000 km^2)

Region	Sea Area	Continental Shelf
Western Bering Sea2/	1,340	320
Okhotsk Sea	1,590	620
Japan Sea	978	250
Pacific Ocean	-	1603/
Yellow Sea and East China Sea4/	1,169	940
Northwestern South China Sea	8605/	4806/

1/ Mostly from Moiseev (1971).
2/ West of 175°W, estimated by the author from the whole sea/shelf areas in the Bering Sea.
3/ From south Kamchatka to the southern end of Japan.
4/ Includes the Po-Hai Sea.
5/ Estimated by the author.
6/ After Gulland (1971).

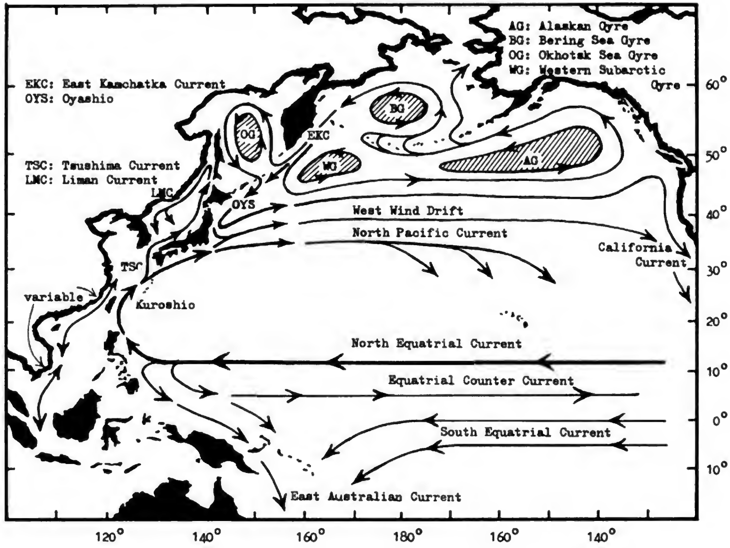

Figure 2. Schematic illustration of the principal ocean currents in the Northwest Pacific.

2. HYDROGRAPHY

The hydrography of the Northwest Pacific is characterized by cold water masses in the north, warm water masses in the south and a convergence of the two in the central region.

2.1 Pacific Ocean

The region along the Kuril-Japan-Ryukyu chain is markedly affected by two important sea currents in the area. The Kuroshio, a warm current from the tropics and the Oyashio from the Sub-Arctic run along the island chain from the south and north respectively and then converge off the northern part of Japan (around 40°N). This affects not only the climate but also the biological environment in the region. A very rich flora and fauna are found in the central region characterized by Arctic-boreal, temperate and sub-tropical species.

2.1.1 Kuroshio

The Kuroshio originates from the North Equatorial Current, a westerly current which flows along 10-20°N, and later changes to flow north around the Philippines. Along the Philippine Islands and Formosa it is called the Kuroshio and moves in a northeasterly direction past the Ryukyu Islands, and then eastward just south of southern Japan. It leaves the coastal zone around northern Japan (35°-40°N) meandering nearly due east towards the North Pacific current and the West Wind Drift in the North Pacific. Around the Ryukyu Islands, the Kuroshio sends a branch current northwards as the Tsushima Warm Current which flows into the Japan Sea.

South of southern Japan, the Kuroshio runs at a maximum velocity of up to 140-160 cm/sec at the surface and at the centre of the flow. The centre is about 100 km from the coast, and it extends about 200 km from the coast (Tsuchida, 1971). The volume transport of the Kuroshio above 1,500 m depth has been estimated at about 65 million m^3/sec south of southern Japan (Sverdrup et al., 1942). The velocity of the Kuroshio and the volume transport fluctuates throughout the year. It generally appears to increase twice a year, in summer and winter (Masuzawa, 1960, 1965). However, shorter (4 months), or longer (8 and 12 months), cycles are also observed (Nitani, 1975). In addition, a long-term (7-9 years) cyclic change in the velocity and volume transport are also recorded (Nitani, 1975).

The Kuroshio often forms a large-scale meandering off the south-central coast of Japan (Uda, 1949, Taft, 1970, Nitani, 1975). This is usually accompanied by a large cold water eddy inside, and a few small cold or warm water eddies outside, (Rikiishi, 1974, Nishiyama et al., 1980). The current velocity decreases through the course of the meandering down to 100-130 cm/sec. The occurrence and magnitude of this meandering are quite variable (Taft, 1970, Nitani, 1975) and can sometimes affect sea conditions considerably along the coast of Japan (Ishino et al., 1970, Kawabe, 1980).

The temperatures of the Kuroshio are comparable to those of the Gulf Stream in the North Atlantic (25-27°C at the surface layer in summer), but the salinities are much lower and at a maximum slightly less than 35.00 ‰ (compared with about 36.50 ‰ for the Gulf Stream). The vertical gradient of temperature is rather indistinct during January to May and the transparency decreases due to a thick concentration of diatoms in the upper layer. During June to November, on the other hand, a density stratification develops associated with a striking discontinuity of temperature and chlorinity around a depth of 100 m.

2.1.2 Kuroshio Extension and further north

The Kuroshio Extension, which is the direct continuation of the Kuroshio, leaves the coast of Japan dividing into two branches. The major branch turns due east around 35°N keeping the characteristics of the Kuroshio up to 160-170°E. It then forms a further easterly current, the North Pacific Current (Sverdrup et al., 1942). Another branch continues northeasterly and flows along the Japanese coast as far as 40°N where it turns towards the east. This northern branch becomes rapidly mixed with the cold water of the Oyashio from the north. It then maintains a north-north easterly flow and forms Sub-Arctic water (Hirano, 1957, 1957a, 1958) which is continuously mixed with cold water from the north as far as 180°E. Eventually this forms the West Wind Drift which continues as an easterly flow across the Pacific Ocean until it reaches the Alaskan Gyre in the northern Northeast Pacific (Sverdrup et al., 1942, Dodimead et al., 1963). The convergence of the Kuroshio Extension and the Oyashio creates very complicated oceanographic condition along the coast of northern Japan which is discussed in the sub-section on the Oyashio.

North of the northern branch of the Kuroshio Extension, a counter-clockwise gyre of Sub-Arctic water exists in the waters south of the southeast Kamchatka and western Aleutian Islands, which is called the Western Sub-Arctic Gyre (Hirano, 1958, 1961, Dodimead et al., 1963).

Further north another large counter-clockwise gyre exists in the Western Bering Sea, an outflow of which forms the origin of the Oyashio.

2.1.3 Oyashio

The East Kamchatka Current, is a cold water flow which originates from the outflow of the water masses of the Bering Sea Gyre, and runs along the east coast of the Kamchatka Peninsula and Kuril Islands towards northern Japan. A branch of the East Kamchatka Current flows into the Okhotsk Sea through the northern Kuril Islands and moves counter-clockwise around the Okhotsk Sea Gyre. The further-cooled water masses flow out from the Okhotsk Sea through the southern Kuril Islands to again join the main flow of the extension of the East Kamchatka Current to form the Oyashio (Dodimead et al., 1963). Another branch of the extension turns its direction to the east off Hokkaido (around 45^{o}N) and then flows into the Sub-Arctic Current which flows eastwards across the Pacific Ocean (Dodimead et al., 1963). A recent analysis of satellite images has shown that the water movement of the East Kamchatka Current is highly complex, forming a number of spiral-arm type eddies - accompanied by an upwelling at the centre (Solomon et al., 1978).

The volume of water transported above 1,500 m deep for the cross-section off the northern Kuril Islands has been estimated at about 15 million m^3/sec, one-third of which comes from the Okhotsk Sea and another one-third from the Bering Sea (Sugiura, 1958). One of the permanent features of the Oyashio is a halocline found at a depth of about 100 to 200 m. In the upper layer, a marked thermocline develops during the summer. Vertical mixing becomes progressively deeper during the cooling season but generally stops at the depths of the permanent halocline (Dodimead et al., 1963). The surface temperature of the Oyashio off the southern Kuril Island is 6-10^{o}C in summer and 1-2^{o}C in winter. In summer, the salinities are 32.5-33.0 ^{o}/oo in the upper layer and the visibility is about 13-19 m. Both sets of figures are much less than in the Kuroshio.

The waters off northern Japan where Oyashio from the north and the Kuroshio from the south converge (33-43^{o}N, 141-150^{o}E) show the largest oceanographic complexity in the area (Hikosaka et al., 1957, Hirano, 1957, 1958, Hata, 1969, 1969a, Iida et al., 1974). The Oyashio generally sinks down under the Kuroshio and is rapidly mixed with the warm waters from the south. Numerous eddies of warm and cold waters are usually created, and mixing takes place with surrounding waters. Some of these eddies are huge and occasionally move far to the south (Oyashio origin) or north (Kuroshio origin) from the boundary of the two currents. Such dynamic changes in the development of eddies considerably affect not only the oceanographic and climatic condition along the Japanese coast, but also biological conditions. The convergence generally creates favourable conditions for the existence of a very rich flora and fauna along the Japanese coast, but sometimes creates fatal conditions for the biota.

2.2 Okhotsk Sea

There is a very cold counter-clockwise gyre in the central part of the Okhotsk Sea which is called the Okhotsk Sea Gyre (Dodimead et al., 1963). A cold water mass flows around the gyre, also in a counter-clockwise direction. This originates from the East Kamchatka Current and passes through the northern part of the Kuril Islands. The water, which is further cooled, flows out of the Okhotsk Sea through the southern Kuril Islands and joins an extension of the East Kamchatka Current to form the Oyashio.

The climate in the Okhotsk Sea in winter is the most severe in the entire area (Sverdrup et al., 1942, Zenkevich, 1963, Akagawa, 1972) and the sea is covered with heavy sea-ice during winter to spring (Great Britain Hydrographer of the Navy, 1966, USSR Ministry of Defence, 1974). The ice-cover starts in November along the north and west coasts, it then extends to the entire coast and to the offshore area. From January to April the first-ice extends 25 to 35 miles offshore along the north and west coasts and the rest of the sea is covered with heavy drift-ice except for the southeastern part of the sea along the Kuril Islands and the tip of the Kamchatka Peninsula. The maximum ice-cover occurs in February and March, when only a small part generally remains ice-free. In an extremely severe year the entire area is completely ice-covered. The general break-up of sea-ice occurs in May which starts from the east and south. Much of the broken ice is carried west and south, and within a fairly short period, the greater portion is carried to, and dispersed in, the Pacific Ocean through the southern Kuril Islands. However, even in mid-May about one-third of the sea in

the west is still generally covered with ice. The ice-free area thus extends over the entire sea for only half the year, late-May to mid-November.

Vertical mixing occurs in winter but the permanent halocline structure confines mixing to the upper 50-100 m layer and a cold intermediate layer develops throughout the year. Even in summer, the temperature at a depth of 100 m to 200 m is as low as -1.4°C. This is why the above-mentioned flow, a component of Oyashio, is cooled in the Okhotsk Sea. The salinity of the waters in the Sea is also low being about 32.2-33.0°/oo in summer which is almost equivalent to that in Oyashio (Dodimead et al., 1963). It is not clear whether the salinity in winter is increased so much by freezing.

2.3 Japan Sea

A warm and a cold current characterize the hydrographic nature of the Japan Sea. The Tsushima Warm Current flows along the Japanese coast from the south, and the cold Liman Current flows along the USSR and northeastern Korean Peninsula coasts from the north (Great Britain Hydrographer of the Navy, 1966). However, no complicated convergence, divergence or meandering are formed by these two currents.

2.3.1 Tsushima Warm Current

The Tsushima Warm Current, which is a branch of the Kuroshio, diverges around the Ryukyu Islands and then moves to the north along the west coast of Kyushu, and flows into the Japan Sea through the Korea Strait. It carries water of a high temperature and high salinity to the north mainly along the coast of Japan. The surface velocity of the current in the Korea Strait is strongest in summer at about 100-110 cm/sec. It reaches up to the southeastern part of the Tatar Strait in summer and flows along the coast of northern Japan and Sakhalin. However, substantial amounts of water flow out partly into the Pacific Ocean through the Tsugaru Strait, and partly into the southern Okhotsk Sea through the Soya Strait. The outflow speed through the Soya Strait in summer is about 24-25 km per day. The current hardly reaches the Tatar Strait in winter, and it appears that most of the water flows out through the Tsugaru Strait at a speed of 35-37 km/day (Great Britain Hydrographer of the Navy, 1966). The volume transport calculated for the cross-section east of the Korea Strait shows a maximum of 2.2 million m^3/sec in March. It is noteworthy that only one minimum is observed in a year in the Japan Sea in comparison with two possible maxima in Kuroshio (Miyazaki, 1952, Hata, 1962).

The surface salinities along the northern coast of Japan are about 33.0-33.60 °/oo, a little higher than in Oyashio, while those along the southwestern coast of Japan are 33.8-34.0 °/oo, slightly lower than in the Kuroshio. That is to say the difference is not so sharp between the waters in the north and south as in the Pacific Ocean (Sverdrup et al., 1942, Fukuoka, 1962, Kano, 1980).

The surface temperature in summer remains almost the same throughout the current in the Japan Sea, 25-27°C, equivalent to that in Kuroshio. However, it drops down to 8-10°C in winter along the central and northern coasts of Japan (Sverdrup et al., 1942, Miyazaki, 1952, Kano, 1980).

The Tsushima Warm Current sends small branches to the north in the southern part of the Sea in summer. One branch runs along the east coast of the Korean Peninsula. The other proceeds counter-clockwise to the offshore area off the Peter the Great Bay and the southwest coasts where a cooler environment prevails during the remainder of the year.

2.3.2 Liman Current

A cold current flows southward along the western coast of the Tatar Strait. It is not likely however that the water mass originates from the Okhotsk Sea as the Strait is very narrow and shallow, being only 6.7 km wide and 12 m deep. The cold water must therefore have been formed in the Japan Sea by excessive cooling in winter and must have been diluted by cold water from many rivers along the Siberian coast. It is also probable that the extension of the Tsushima Warm Current which runs up to north along the west coasts of Hokkaido and Sakhalin, turns round in the Tatar Strait after having been cooled and diluted and is eventually mixed up with water masses in the Liman Current (Sverdrup et al., 1942, Great Britain Hydrographer of the Navy, 1966).

The current is at its greatest in winter when it passes down to the southwestern part of the Sea along the western coasts. In summer, however, it reaches only to the northeastern base of the

Korean Peninsular (40^{o}N) and turns round to the east when the branch of the Tsushima Warm Current prevails further south. The current velocity at the surface appears to be comparatively lower than in other currents in the Northwest Pacific, being about 30-40 cm/sec in winter (Great Britain Hydrographer of the Navy, 1966).

The surface temperature in summer attains about 20-22^{o}C off the Peter the Great Bay but decreases sharply in winter to slightly above 0^{o}C (Kano, 1980). Cooling in winter is due mostly to the excessively cold wind from Siberia and the climate is more severe in the northwestern part of the Sea. The Tatar Strait is covered by ice during November to May. Shallower parts further south, along the Siberian coast (coves, bays, harbours and rivers), are usually blocked by ice. A thin coating of ice is also formed along the east coast of the northern Korean Peninsula. As a result of the sinking of cold surface waters along the slopes, the deep waters are well aerated and characterized by their lower temperatures and by the absence of any oxygen deficiency i.e., temperature: 0.15-0.19^{o}C, Salinity: 34.03-34.09^{o}/oo, Oxygen: 5.7-6.0 ml/l at 500 m deep (Sverdrup et al., 1942, Zenkevich, 1963, Kano, 1980). An analysis indicates that an ascending motion may appear in the central part of the sea (Fukushima, 1965). Intensive vertical mixing in winter is also observed in the southeastern part (Koshimizu, 1958). Unusual development of the cold deep water masses from north and west sometimes affects the hydrographic condition along the Japanese coast (Kitani et al., 1969).

2.4 Yellow Sea and East China Sea

The region is characterized by three distinct water masses. These are: (1) the Kuroshio and a branch (the Tsushima Warm Current), which flows along the eastern boundary of the seas, (2) a cold water mass originating from the northern Yellow Sea and the northern Chinese coasts, and (3) a warm monsoon current from the South China Sea (Great Britain Hydrographer of the Navy, 1968, 1978; Sawara, 1974). The hydrographic condition in the region shows a clear seasonal change in connection with the seasonal rise-and-fall of these water masses.

During the winter cold air moves from the Asiatic continent over these seas. The overall cooling of surface water and the following convection allows an equalization of the temperature of sea water from the surface to the bottom. The strong cold winds caused by the continental high atmospheric pressure accelerates the southward expansion of cooled water from the Yellow Sea to the East China Sea along the Chinese coast. It flows into the northern South China Sea through the Formosa Strait during October to February. The maximum speed of this current reaches about 50-55 cm/sec. The surface temperature is lowest in February. In the Yellow Sea it ranges from about 0^{o}C in the northernmost part to about 10-13^{o}C along the boundary of the East China Sea, the line between Shanghai and Cheju-do Island. Coastal waters in the East China Sea are also cooled down to 11-15^{o}C in February while the offshore waters, where the Kuroshio and Tsushima Warm Currents flow, remain at a relatively high temperature, 16-21^{o}C during the winter. With excessive cooling in the north, a coating of ice is formed along the northernmost coast of the Yellow Sea, including the entire Po-Hai Sea, during November to March.

During the summer season the winds blow from the southeast at an intensity comparable to that in the winter period. A warm monsoon current which originates from the South China Sea flows into the East China Sea through the Formosa Strait and proceeds along the Chinese coast up to the central Yellow Sea at a velocity of about 30-40 cm/sec. As a result of the warm Kuroshio and the Tsushima Currents which are also strongest in summer, the surface temperatures are considerably higher in August; 28-29^{o}C in the East China Sea and 24-27^{o}C in the Yellow Sea.

Besides the currents the strength of the tide is another important aspect of the hydrography in these seas. It is particularly strong on the western coast of the Korean Peninsula, the range between the high and low tides reaching about 3-9 m in some places and seasons with strong tidal streams of 5-8 knots.

2.5 Northwestern South China Sea

The region is almost entirely under the monsoon regime in the South China Sea (Wyrtki, 1961, Great Britain Hydrographer of the Navy, 1978), that is, a southwesterly current prevails during winter and a northeasterly one in summer. The average surface temperatures and salinities are 16-23^{o}C and 33.5-34.2 ^{o}/oo in the former season and 28^{o}C and 33.0-33.5 ^{o}/oo in the latter.

It is noted as was described in the previous sub-section that cooler water masses from the East China Sea flow down to the region along the Chinese coast which enables some species of temperate fauna and flora to exist along the Chinese coast.

3. PLANKTON

Many plankton studies have been reported but most of them are limited to particular localities or species, and are of a more or less qualitative nature. The general features of plankton distribution in the Northwest Pacific have been well summarized in some works (Shimomura, 1957, Bogorov, 1958, Motoda et al., 1965, Zenkevich, 1963, Kawarada et al., 1966, Ohwada et al., 1966, Marumo, 1967).

3.1 Phytoplankton

In the Pacific Ocean, the phytoplankton populations in the Oyashio region are generally composed of boreal diatoms, while in the Kuroshio region they are typically warm-water species. The phytoplankton between the southern coasts of Japan and the Kuroshio is strongly neritic in nature. It is interesting to note that along the convergence of the Kuroshio and Oyashio some neritic diatoms predominate offshore even as far as about 600 miles from the coast (i.e. to about 155°E).

The ocean weather stations have provided valuable information on the seasonal cycle of the phytoplankton in the high seas region (Kitou et al., 1956). At station X (39°N, 153°E), for example, which is alternatively under the influence of the Oyashio or the Kuroshio water, a bimodal cycle of production is observed with peaks in spring and autumn. At station T (29°N, 135°E) in the area of the Kuroshio water, the phytoplankton develops in late winter to spring. The seasonal cycles along the coasts vary according to locality. In the Kuroshio water south of Japan for example, the greatest concentration of diatoms is found in the upper 25 m layer during January to May. The concentration of diatoms during June to November, on the other hand, is separated into two layers, one in the upper 10 m and the other at about 100 m depth, probably because of the nature of the stratification.

The concentration of phytoplankton in the Oyashio region is generally high at 10^4 to 10^6 cells/l, while in the main flow of Kuroshio it is usually about 10^2 to 10^4 cells/l, and in a vast region further south it is less than 10^2 cells/l. In the neritic waters along the west and south coasts of Japan the concentration is usually in the order of 10^3 to 10^4 cells/l.

The same phenomenon generally appears in the Japan Sea. The concentration in the northern part of the sea reaches 10^5 to 10^6 cells/l, comparable to the concentration in the Oyashio region (Zenkevich, 1963). In the central Japan Sea the concentration in winter is observed to be about 10^4 cells/l, while in summer it decreases to 10^2 to 10^3 cells/l (Ohwada and Ogawa, 1966, Kawarada et al., 1966). In the southern and eastern part of the Sea, where the Tsushima Warm Current prevails, the concentration is moderate at 10^3-10^4 cells/l (Kawarada et al., 1966). The western part of the Sea, where the cold Liman Current water dominates throughout the year, is characterized by a paucity of phytoplankton with 5×10^2 cells/l in winter and 10^3 cells/l in summer (Kawarada et al., 1966).

In the northern Okhotsk Sea, there is only a single bloom by some Arctic boreal species during late spring to summer because of the severe climatic conditions during late autumn and winter. At the height of the bloom the concentration may reach about 7×10^8 cells/l, which is the largest recorded for the regions in the Northwest Pacific (Zenkevich, 1963). A notable feature is that this high concentration is realized only in the surface to sub-surface layers of the Sea due to the presence of the cold intermediate layer. The concentration decreases markedly at 40-50 m deep to about 1/40th of that in a 0-10 m layer (Zenkevich, 1963). In the southern Okhotsk Sea the concentration is observed to be less than 10^2 cells/l, except for the coastal waters near the Soya Strait (Kawarada et al., 1966).

In the East China Sea the distribution of phytoplankton is separated into two. In the south and east there are warm water species originating from the Kuroshio and Tsushima Warm Currents. In the north and west including the central part of the Sea, which is affected by cold water from the north and from the Yellow Sea there are cold water species (Kawarada et al., 1966, Asaoka, 1975). The distributions of the two groups change reciprocally in accordance with the seasonal change in the magnitude of the two water masses. The phytoplankton concentration in the warm water is nearly equivalent to that of the Kuroshio, (5×10^2 to 5×10^3 cells/l in winter and 10^2 to 10^3 cells/l in summer). In the colder water, the concentration is slightly lower, usually less than 10^3 cells/l. A notable phenomenon in the region is that extraordinary blooms of a blue-green algae, *Trichodesmium*, are quite often observed during summer (Aruga, 1975).

3.2 Zooplankton

In the Pacific region the distribution of boreal copepods is limited to the north of the Kuroshio Extension. Tropical or sub-tropical copepods are generally distributed in the Kuroshio region and further south. Their distribution shows little seasonal change. The majority of the zooplankton occurs between 0 and 100 m depth. In the Kuroshio region the biomass(wet weight) in the upper 100 m is usually less than 50 mg/m^3 on the oceanic side of the current, while it is 50 to 180 mg/m^3 on the neritic side (Kawarada et al., 1966), and there is no distinct seasonal change (Motoda et al., 1965). In the Oyashio region the biomass is generally small in the winter and less than 50 mg/m^3, especially in the waters east of Hokkaido (Kawarada et al., 1966). In the northern part of the Oyashio, Kuril-Kamchatka region, the biomass shows high values in summer of about 250 to 600 mg/m^3 (Vinogradov, 1972). In both the Kuroshio and Oyashio regions the species composition of zooplankton varies by depth and the total biomass decreases sharply at a depth of 200-300 m (Vingradov, 1972, Marumo et al., 1976).

In the Japan Sea the northern and western parts are occupied by cold water species which are affected by the cold Liman Current. The south, and the southeastern parts of the Sea where the Tsushima Warm Current prevails, are occupied by warm water species.

In the northern Okhotsk Sea where cold water species are predominant throughout the year, the zooplankton biomass in the upper 50 m depth layer reaches a maximum during the spring bloom of 2,000 to 3,000 mg/m^3. This is the largest biomass for the regions in the Northwest Pacific as is also the case for the phytoplankton there. As was also observed for the phytoplankton, the biomass generally decreases markedly at depths of 40 to 50 m. It increases slightly again below the cold layers at a depth of 100 to 150 m (Zenkevich, 1963). In the southern Okhotsk Sea the zooplankton biomass in summer ranges from 90 to 300 mg/m^3, with an average of 180 mg/m^3. It is usually low in the offshore waters (Kawarada et al., 1966).

In the East China Sea the biomass of zooplankton is generally low in the Kuroshio and Tsushima Warm Current regions with a range of 12 to 112 mg/m^3 in summer. It is extremely large however in the waters over the continental shelf ranging from 82 to 473 mg/m^3 in summer (Kawarada et al., 1966). This high biomass appears to persist all the year round especially in the central part of the sea (Irie et al., 1972).

4. PRIMARY PRODUCTION

Information on primary production in the area is still too fragmentary and the coverage is too unsatisfactory in time and space to allow any reliable estimate of annual production. Some estimates, however rough and unsatisfactory they may be, are made in this paper, as these should be useful for comparing the levels of production in the various regions.

4.1 Pacific Ocean and Further North

The waters along the Pacific coast of Japan where the Kuroshio runs from the south and the Oyashio from the north is the only region in the area where substantial surveys and studies have been carried out, including the direct measurement of productivity, though the data are still insufficient to be used for detailed analyses.

As far as primary production is concerned, it has been generally accepted that the water masses in the Kuroshio region are relatively unproductive next to those in equatorial regions. On the other hand the Oyashio region is one of the most productive regions comparable with other productive regions in the world such as the northeast and northwest Atlantic Oceans (Sverdrup, 1955, Ryther, 1963, Koblents-Mishke, 1965). It has also been found, through recent studies, that the littoral waters along the Kuroshio are nearly as productive as the Oyashio region.

4.1.1 Kuroshio region

The euphotic or photosynthetic zone, (i.e. the zone extending to a depth at which light intensity is only 1 percent of that at the surface), is usually deep, ranging from 80-100 m in summer and 60 to 90 m in the winter (Aruga et al., 1968, 1968a). It occasionally extends deeper, to 150 m in summer. In connection with this feature, primary production shows a gradual decrease with depth to 40-50 m, however, low production is observed even in 90-100 m layers on a clear day (Aruga et al., 1962).

The daily gross production in summer for the entire euphotic zone per m^2 sea surface was directly measured for three different weather conditions. The values were 0.36, 0.29 and 0.16 $gC/m^2/day$ on a clear, a slightly cloudy and a cloudy day respectively. Taking the weather conditions into account, the daily gross production per unit sea surface is therefore estimated to be about 0.2-0.3 $gC/m^2/day$ (Aruga et al., 1962). Assuming the rate of respiration is 40 percent of the gross production (Steeman Nielsen, 1958), the net primary production is estimated to be about 0.1-0.2 $gC/m^2/day$. By comparison, the results of direct measurements of the daily net production in summer carried out more recently showed slightly higher values, i.e. 0.3, 0.2 and 0.1 $gC/m^2/day$ on a clear, a cloudy and a rainy day respectively (Aruga et al., 1968). Although the seasonal change in primary production in the region has not been studied well, it was ascertained through direct measurements carried out during February and early March, that a fairly high productivity is likely to be maintained even in the winter in spite of the low water temperatures, with at least 0.3 $gC/m^2/day$ of gross production (Aruga et al., 1968a) or about 0.18 $gC/m^2/day$ of net production. In summary, it is estimated that the average daily net production in the Kuroshio region is about 0.15-0.25 $gC/m^2/day$ and that the annual net production would be about 55-90 gC/m^2.

The level of primary production in the littoral zone of the Kuroshio is greater than that in the oceanic regions and somewhat resembles that of the Oyashio. The euphotic zone is shallower with a depth of 40-60 m throughout the year (Aruga et al., 1968, 1968a, Shimura et al., 1972). Primary production is considerably higher than that in the oceanic Kuroshio regions and shows a seasonal change, high in summer and low in winter, values are from 0.5-1.5 $gC/m^2/day$ in summer and 0.2-0.3 $gC/m^2/day$ in winter for gross production (Noda et al., 1967, Shimura et al., 1972). The average daily gross production in the region is estimated, excluding some extremely high and low values, to be about 0.4-0.6 $gC/m^2/day$ which is close to that for the Oyashio. The daily and annual net primary production are accordingly estimated to be 0.25-0.35 $gC/m^2/day$ and 90-130 $gC/m^2/year$.

4.1.2 Oyashio region

The euphotic zone in the Oyashio region is shallower than that in the Kuroshio with a depth of 40-60 m in summer and winter (Aruga et al., 1968, 1968a). The level of primary production shows a sharp decline around the 10-20 m depth layer and no production is observed in waters deeper than 60 m in contrast to that in the Kuroshio region though the total primary production in the euphotic zone in the Oyashio is larger than in the Kuroshio (Aruga et al., 1962).

As in the Kuroshio region, direct measurements of primary production were carried out. In summer, the daily gross production for the entire euphotic zone per m^2 in three different weather conditions was 0.83, 0.72 and 0.49 $gC/m^2/day$ on a clear, a slightly cloudy and a cloudy day respectively. The probable ranges of the daily gross and net productions were then estimated to be 0.6-0.8 $gC/m^2/day$ and 0.4-0.5 $gC/m^2/day$ respectively assuming that respiration accounts for about 40 percent of gross production (Aruga et al., 1962). Even in winter, the measured daily gross production was fairly high, in spite of the low temperature, with a range of 0.3-0.8 $gC/m^2/day$. Under some favourable conditions associated with a high incidence of light and a large phytoplankton biomass there were occasional values of up to 1.5 $gC/m^2/day$ (Aruga et al., 1968a). The average daily net production in winter is estimated to be about 0.2-0.5 $gC/m^2/day$ which is only slightly lower than that in the summer. Details of the seasonal variations in productivity are not so clear. Some measurements have given very high daily gross production in the spring (1.5-1.7 $gC/m^2/day$) and rather low values in summer (0.45 $gC/m^2/day$) in the Oyashio region (Taniguchi et al., 1972). It is not clear however how representative these figures are of the seasonal variation in primary production due to insufficient coverage in time and location.

Taking all the Information together, the overall level of daily net production in the region is estimated to be about 0.3-0.4 $gC/m^2/day$ which gives an annual net production of 110-150 $gC/m^2/year$. This agrees well with the other estimates of annual gross production of 200-250 $gC/m^2/year$ by Aruga et al., (1968a) and 160 $gC/m^2/year$ by Taniguchi, (1972). It therefore appears that primary production in the Oyashio region is about twice that for the Kuroshio region.

4.1.3 Western Bering Sea

This is one of the regions where information is very sparse both in time and location. In addition to the lack of data, sea-ice formation during winter to spring has made it difficult to estimate the annual production for the region. The region generally appears to rank as one of the fairly productive regions and may be comparable to the Oyashio region (Koblents-Mishke, 1965, Koblents-Mishke et al., 1970, Sanger, 1972). However, details of seasonal variation and an overall evaluation for the region are very vague.

A very short productive season due to the sea-ice and the severe climate during winter to spring, is one of the striking characteristics of the region, and this is assumed to be so in the Okhotsk Sea also as discussed in the following sub-section. The northern and western parts are covered with ice, affecting about 20-30 percent of the entire region during February to April and about 10 percent in December, January and May (USSR Ministry of Defence, 1974). The ice grows to about 1-2 m thick and heavy snow, which is believed to reach about 50 cm deep also covers the ice (McRoy et al., 1974). The weather conditions in terms of total radiation, overcast, temperature and wind are, of course, very unfavourable for primary production during these seasons.

In summer a few data on the daily gross primary production were collected through direct measurement in the central and southern Bering Sea. The average of these estimates is: 0.340 gC/m^2/day in the Bering Sea Gyre, 0.630 gC/m^2/day in the southeastern part of the Gyre (Taguchi, 1969), about 0.333 gC/m^2/day along the central Aleutian Islands (McRoy et al., 1972) and 0.330 gC/m^2/day in the central Bering Sea (Taniguchi, 1972). These estimates correlate well with that of the phytoplankton concentration in the region in summer (Motoda et al., 1974) with the exception of the waters along the Aleutian Islands where fairly high plankton biomass exists, but the observed productivity was not so high.

Only a little information is available for winter and spring. The daily rate of gross primary production was estimated to be only 0.015-0.021 gC/m^2/day for the water under the ice and 0.089 gC/m^2/day for the water in the ice-front in the eastern Bering Sea during February to May (McRoy et al., 1972, 1974). It is notable that an algal community exists in the ice, consisting mostly of pennate-type diatoms - different from ordinary planktonic types - and concentrated near the undersurface of sea-ice. This community showed small but consistent productivity of 2.2-4.8 mgC/m^2/day with occasionally values of 44.4 mgC/m^2/day (McRoy et al., 1972, 1974). However, details of seasonal variation and their role in the entire productivity in the water are not known.

The euphotic zone was estimated to be about 40-70 m deep in the open sea in the summer (Taniguchi, 1972) and around 20-30 m in the ice front water during winter to spring (McRoy et al., 1972).

In this paper the primary production under and in the ice during the frozen period is neglected due to its low level. The rate of daily net production for the open sea is estimated for summer and winter, assuming that respiration accounts for 40 percent of the gross primary production.

(a) Summer rate: 0.288 gC/m^2/day

This was estimated from 60 percent of the average of the estimated lowest and highest daily gross productions;

i.e. $0.6 \times (0.330 + 0.630)/2$

(b) Winter rate: 0.171 gC/m^2/day

This was estimated from 60 percent of the average of the daily gross productions in ice-front water in winter, and in open sea in summer;

i.e. $0.6 \times (0.089 + 0.480)/2$.

Assuming that the northern 25 percent of the region is covered by ice during February to April and that the rate of daily net production is comparable to the winter rate for the northern 25 percent of the region during December, January and May, and for the southern 75 percent during December to May, and that the rate is comparable to the summer rate for the entire region during June to November, the overall average of the rate of net production throughout the year for the entire region is estimated as:

$$(0.25 \times 0.171 \times \frac{3}{12}) + (0.75 \times 0.171 \times \frac{6}{12}) + (0.288 \times \frac{6}{12}) = 0.219$$

about 0.22 gC/m^2/day or 80 gC/m^2/year. Possible range of the production would be, allowing about 25 percent error to the estimates, 0.17-0.28 gC/m^2/day or 60-100 gC/m^2/year, which is slightly higher than the Kuroshio region but about 30-40 percent less than the Oyashio region. The estimated ranges accord well with those derived from the oceanographic studies (Koblentz-Mishke et al., 1970, Sanger, 1972).

In addition to future research, observations on the phytoplankton bloom in shallower waters in summer is particularly important. For example, an extremely large production (4.1 gC/m^2/day) was observed in the Bering Strait in June, just outside the region (McRoy et al., 1972). Similar phenomena may be common in other shallow areas such as the Gulf of Anadyr and the coastal waters along the Kamchatka Peninsula. In fact, an extremely large phytoplankton concentration (742.2×10^6 cells/m^2) was observed in the Gulf of Anadyr in summer although no measurements were made of primary production (Taniguchi, 1969), observations on seasonal and annual productivity must therefore be one of the important target studies in the future.

4.2 Okhotsk Sea

Information is very scarce for the Okhotsk Sea. There has been no direct estimate of primary production in the region, and information is limited only to studies made from an overall oceanographic viewpoint (Koblents-Mishke, 1965, Koblents-Mishke et al., 1970, Sanger, 1972). First, the greater part of the sea is covered with heavy sea-ice from winter to spring and this is one of the outstanding features of the area. In the northern and northwestern parts, about 30-40 percent of the sea is ice-bound during almost half the year and this severe climatic condition is evidently one of the limiting factors for organic production in the sea. The phytoplankton starts to bloom immediately after the break-up of sea-ice along the Kamchatka and Siberian coasts. These concentrations are among the largest for the entire area (Zenkevich, 1963). This may be comparable to the sudden increase in the primary production in spring observed in Amur Bay, the northernmost part of the Japan Sea (Kuznetsov, 1980) and may have mainly supported the large spawning stocks of herring and Alaska pollack along the coasts during May to June. However no autumn peak is observed. It is assumed, therefore, that the primary production of the northern coastal waters may well be high, exceeding that of the Oyashio during late spring to summer but comparable to the Oyashio during the rest of the ice-free season. In contrast, in the southern offshore waters in summer with the exception of the coastal waters near the Soya Strait the phytoplankton concentration was lower (Kawarada et al., 1966). It is probable, therefore, that primary production in the southern coastal waters may be lower than in the north, and probably equivalent to that of the Oyashio at its best.

It is probable that the primary production of the central waters may be substantially lower than that of the Oyashio throughout the ice-free season. In this area, the importance of the permanent halocline must be emphasized and recommended as a subject for further biological study.

In this study, the primary production during the ice-bound season is assumed to be negligible, as in the case of the Western Bering Sea. To estimate an overall average rate for the region, the following assumptions were made.

(a) For the ice-free season:

(i) Northern coastal waters (30 percent of entire area)

May to November, 7 months.

(ii) Southern coastal waters (30 percent of entire area)

May to January, 9 months.

(iii) Central waters (40 percent of entire area)

May to January, 9 months.

(b) Daily rates of net primary production:

(i) Northern coastal waters

25 percent higher than the Oyashio during May to August and comparable to the Oyashio during September to November.

(ii) Southern coastal waters

comparable to the Oyashio throughout the season.

(iii) Central waters

25 percent lower than the Oyashio throughout the season.

On these assumptions the average rate of net primary production throughout the year is estimated to be about 0.20-0.26 gC/m^2/day or about 70-95 gC/m^2/year.

These estimates show that primary production in the region is higher than for the Kuroshio main flow region but lower than for the Oyashio region by about 30-40 percent. It is also slightly lower than that in the Japan Sea. This disagrees with the results obtained from oceanographic review studies - which suggest that production in the area is equivalent to or even higher than that for the Oyashio region (Koblents-Mishke, 1965, Koblents-Mishke et al., 1970, Sanger, 1972). The author thinks however that as far as the overall annual rate is concerned, the lower value obtained is likely to be more reasonable when account is taken of the severe climatic conditions during winter to spring.

4.3 Japan Sea

No primary production data are available for this region. However, an approximate estimate of the net primary production is made here based on information on the standing crop of phytoplankton and comparing it with that in the Pacific Ocean and with the level of productivity there. As was described in the previous sub-section, the overall concentration of phytoplankton is the highest in the northern part of the Japan Sea where it is comparable with that in the Oyashio region. It is slightly higher than that in the main Kuroshio but equivalent to that in the littoral zone of the Kuroshio in the southern and eastern part. It is nearly the same as in the main Kuroshio region in the central part. It is lowest in the western and southwestern part of the Japan Sea where it is slightly less than in the Kuroshio region. No large differences have been observed in the standing crop in summer and winter except for in the central part of the Sea (Kawarada et al., 1966, Ohwada et al., 1966).

It is assumed that in each of the above-mentioned four areas the rates of production are equivalent to those of the Oyashio or Kuroshio region, and proportional to the concentration of phytoplankton, assuming then that the relative proportions of each of the areas is approximately 0.4:0.2:0.2:0.2. The range of the daily net primary production for the entire Japan Sea is roughly estimated as:

lower limit:

$$0.4 \times 0.3 + 0.2 \times 0.25 + 0.2 \times 0.15 + 0.2 \times 0.15 \times \frac{5 \times 10^2}{10^3} = 0.215$$

upper limit:

$$0.4 \times 0.4 + 0.2 \times 0.35 + 0.2 \times 0.25 + 0.2 \times 0.25 \times \frac{10^3}{10^4} = 0.285$$

An estimate of the net production is therefore about 0.215-0.285 gC/m^2/day or about 80-105 gC/m^2/year.

Seasonal variations in primary production have been ignored in these calculations, although there may be a large change in the level of production associated with the spring bloom especially in

the northern and central parts. Further studies are therefore required for better estimates in the future. Recent evidence shows that under the ice in the Amur Bay, Tatar Strait in the northern Japan Sea there was a sudden increase in primary production in March when the ice started to thaw, and a level of 1.6 gC/m^3/day-unit was recorded just under the ice. Previously in February, there was no significant production (Kuznetsov, 1980). A similar process may commonly take place in the northern and western parts of the sea along the coast.

4.4 Yellow Sea and East China Sea

This is another region where no definite information on primary production is available. Because of this, and until recently, these Seas had generally been ranked as one of the more productive waters in the world (Koblentz-Mishke et al., 1970). However, some studies carried out in the East China Sea in recent years has revealed that primary production in the region, is not so high as was previously supposed (Aruga, 1975, Hung, 1975, Kozasa, 1979).

As described above, this region comprises three water masses. In the southern Kuroshio the estimated daily net production in summer was 0.044-0.099 gC/m^2/day (Aruga, 1975). Production in the Tsushima Warm Current is more or less the same as in the Kuroshio as it originates from the main flow. However, production in the littoral waters of the Current is presumably as high as in the littoral zone of the Kuroshio. On the shelf area of the East China Sea, where there is cold water from the Yellow Sea and the northern Chinese coast, the estimated daily net production in summer was relatively low at 0.088-0.139 gC/m^2/day. Although the densities of chlorophyll (usually 0.5-2.0 mg/m^3), protein and nucleic acids were as high as those in the Oyashio (Aruga, 1975, Kozasa, 1979). A sharp thermocline is formed on the shelf area at about 15-25 m deep and in the summer a maximum chlorophyll layer generally exists at a depth of 15-35 m. In the main Kuroshio flow no thermocline is formed and the maximum layer is usually deeper than 50 m (Kozasa, 1979). The euphotic zone is estimated to be about 50-60 m deep on the shelf area and 90-120 m deep in the Kuroshio flow (Aruga, 1975). In the southwestern part of the East China Sea, along the east and west coast of Taiwan, Province of China, primary production is generally low in the summer with a daily gross production of 0.2-0.3 gC/m^2/day except for particular coastal localities, (Hung, 1975). It is assumed therefore that at the most the primary production in the southern East China Sea is only slightly higher than in the southern Kuroshio main flow. This may be so even in the summer when the warm monsoon current flows in from the northern part of the South China Sea which is assumed to have more or less the same level of productivity. No information is available for the Yellow Sea or for the entire Po-Hai Sea.

It is assumed that the rate of daily net production in the southeast, which makes up one fifth of the region is comparable to that in the southern Kuroshio main flow. For the east-northeast, which makes up another fifth, it is assumed that production is similar to that in the littoral Kuroshio area. For the remaining three-fifths in the north and west, it is assumed that production is about 80 percent of that in the Oyashio. On this basis the average net production for the entire region is estimated to be about 0.20-0.28 gC/m^2/day or 75-105 gC/m^2/year. This would make the level of production in the area nearly the same as in the Japan Sea. However, further observations are required to obtain better estimates in the future, especially in connection with the extremely large blooms of a blue-green algae Trichodesmium that are observed in summer. These sometimes result in a sharp increase in chlorophyll density, up to about 1.6-10.0 mg/m^3 (Aruga, 1975). The contribution of these blooms to the primary production and their role in the nutrient circulation are not known.

4.5 Summary for Primary Production

As summarized in Table 2, the annual rate of net primary production per unit area is highest in the Oyashio region (130 gC/m^2/year) and lowest in the Kuroshio region (73 gC/m^2/year). These differ by a factor of almost two. It is notable, however, that the littoral zone of the Kuroshio shows the second highest level of production for all the regions with a level of 110 gC/m^2/year. This is only slightly lower than that in the Oyashio, and may help to explain why there is such a large biota along the Pacific coast of Japan. The convergence of the Oyashio and Kuroshio off the northern coast of Japan may have also played an important role in maintaining the nutrient supply through the mixing of cold highly productive water with warm less productive water.

In other regions the productivity per unit surface area is at a moderate level with a range of 80-93 gC/m^2/year. In the northern two regions, the Western Bering Sea and the Okhotsk Sea a very large spring bloom is believed to take place in coastal waters and this may have supported the spawning of large fish stocks there such as herring and Alaska pollack.

Table 2

Estimated annual net primary production by region.

Region	Sea Area (1,000 km^2)	Primary Production: Unit Area ($gC/m^2/Yr$)	Primary Production: Total Area (10^6 tons C/Yr)	Primary Production: Regions Combined 1/ (10^6 tons C/Yr)
Western Bering Sea	1,340	80	107	
Pacific Ocean				
Oyashio region	(1,000) 2/	130	130	314
Kuroshio region	(900) 2/	73	66	
Littoral zone of Kuroshio	(100) 2/	110	11	
Open sea area	?	?	?	? 3/
Okhotsk Sea	1,590	83	137	137
Japan Sea	978	93	91	91
Yellow Sea and East China Sea	1,169	90	105	182
Northern South China Sea	860	?	(77) 4/	

1/ Combined regions to accord with the sub-areas employed in this study.
2/ Areas of the Oyashio region and the entire Kuroshio region were roughly estimated by the author. These are each nearly equivalent to that of the Japan Sea. See Figures 1 and 2.
3/ Open sea area of Pacific Ocean is excluded, so the area is rather irrelevant to the subject.
4/ Rate of primary production per unit area was assumed to be equivalent to that in the Yellow Sea and the East China Sea.

It is well known that the relationship betweeen primary production and fish production is complex. The direct comparison of the two has therefore little value from an analytical point of view, particularly as there is so little information on zooplankton production. However, a comparison of the ratios of fish production to primary production in the various regions may be of some value. In this comparison the northern and southernmost two regions, the Western Bering Sea and northern South China Sea, have to be combined with the neighbouring inner two regions, the Pacific Ocean and the East China Sea respectively because the statistics of fish production are inseparable for these outer two regions. Another assumption made here is that the sea-areas of each of the Oyashio and Kuroshio regions are limited to $1,000 \times 10^3$ km^2 along the Japanese coast, which is about the same as the area of the entire Japan Sea. This is because the vast open area on the high seas is considered to have less linkage with the fisheries production along the Japanese coast. The Kuroshio region can appropriately be further sub-divided into two: the littoral zone (about one tenth of the applied area) and the offshore zone. Primary production in the northern part of the South China Sea is assumed to be the same as that in the East China Sea due to the lack of data though in reality it may be higher. The results obtained are summarized in Table 3.

Table 3

Current yield[1/] compared with primary production,[2/] sea area[3/] and shelf area[4/] by sub-area.[5/]

Sub-Area	Per Primary Production (tons/ton C)		Per Sea Area (tons(km²)		Per Shelf Area (tons/km²)	
	Total	Fish	Total	Fish	Total	Fish[6/]
Bering Sea and Pacific Ocean [7/]	0.019	0.015	1.75	1.39	12.18	9.71
Okhotsk Sea	0.025	0.024	2.05	1.96	5.26	5.03
Japan Sea	0.028	0.024	2.59	2.27	10.13	8.88
Yellow Sea and East China Sea	0.049	0.029	4.41	2.62	6.31	3.75

1/ Total production, which includes aquaculture without feeding (shellfishes and seaweeds) and excludes mariculture with feeding (silver seabream and Japanese amberjack). See Table 5-(2) and 5-(3).
2/ As shown in Table 2.
3/ As shown in Table 1 but a special limitation was applied to the Pacific Ocean as defined in Table 2.
4/ As shown in Table 1.
5/ Sub-area to accord with the combined region in Table 2. See text for the definition.
6/ If major pelagic fishes are excluded, the figures are 2.94, 4.87, 3.89 and 2.58 for each sub-area. See text.
7/ Sea area and shelf area in the sub-area are, as defined above, 3,340,000 km^2 and 480,000 km^2 respectively.

The total yield per unit primary production varies widely among the regions ranging from 0.019-0.049 tons/ton C. The lowest value which is for the Bering-Pacific-combined region, may be underestimated. This is partly due to the rather arbitrary definition of sea-areas adopted for the calculation of primary production in the Pacific region and partly because of the inclusion of the central deep-sea area in the Western Bering Sea area. There, the connection between primary production and fish yield may be the weakest. The particularly high value for the combined Yellow Sea-East-South China Sea area is mainly caused by the high yields of seaweeds which make up 21 percent of the total and other animals which make up a further 21 percent. These include cephalopods, crustaceans, shellfishes-snails and clams when these are taken into account, the fish yield per unit of primary production shows comparatively little variation between the regions with the exception of the low value for the Bering-Pacific region which is referred to above. Along the northern Chinese coast, there is a remarkably large yield of seaweeds, especially that of kelp, Laminaria japonica. In 1979 this accounted for about 1.5 million tons which is about 32 percent of the total Chinese yield. This indicates that the shallower waters of the Yellow Sea and East China Sea are productive and suggests that primary production in these waters may be higher than that in the offshore area. However, details are not known.

The yield per unit-area shows a more or less similar trend to the yield per unit of primary production throughout the region. It is interesting to note that the yield per unit primary production and the yield per unit-area show fairly good agreement for the Okhotsk Sea and Japan Sea, even though it has been generally accepted that the former region is more productive than the latter. The fish yield per unit-area is highest in the Yellow Sea-South China Sea region. This, however, does not necessarily indicate that it has the highest productivity of the entire region. For instance, if the catches of major coastal pelagic fish species taken along the coasts of Japan and Korea Rep. are excluded, the yield per unit-area for the Yellow Sea-South China Sea would be about 1.5 to 1.8 tons/km^2. This is lower than that for the Okhotsk and the Japan Seas and about the same as the smallest value for the Bering-Pacific region.

The fish-yield per unit shelf-area is highest in the Bering-Pacific region and lowest in the Yellow Sea-South China Sea. These differ by a factor of three. The actual values appear to have been greatly affected by variations in pelagic fish production in each of the regions. If the catches of the major pelagic fish species, such as herring, saury, sardine, anchovy, mackerel, yellowtail and tunas are excluded, the fish-yield per unit shelf-area becomes reduced to a level of 2.6-3.9 tons/km^2 except for the Okhotsk Sea where the yield depends mostly on demersal fish. In the Bering-Pacific region the reduction is about 30 percent and in the Japan Sea it is about 45 percent. This is consistent with the high level of pelagic fish production in these two regions, especially in the waters around Japan, and also with a high level of primary production for supporting these stocks.

5. BENTHOS

Due to sampling difficulties, and the cost of surveys, only a few studies have been carried out on the distribution of benthos except in some bays or inlets (Horikoshi, 1962, Moiseev, 1953, 1955, 1971, Zenkevich, 1955, 1963). Other difficulties and inconsistencies in the sampling/screening instruments (volume and mesh-size) between surveys and in the definition of the largest size of animal to be excluded or included. It is hoped that a world-wide standardization of sampling instruments and methods is soon established so that data can be more efficiently analyzed.

The Okhotsk Sea is the best surveyed area among the regions in the Northwestern Pacific. The coastal flora along the north and west coasts of the Okhotsk Sea is composed of about 162 species while the flora along the Kuril Islands is richer, with about 227 species. This is due to the favourable oceanographic conditions there associated with the penetration of oceanic and warmer waters from the Pacific Ocean (Zenkevich, 1955, 1963). The distribution of bottom animals can be classified with reference to their feeding habits into groups such as sestonophages, detritus-feeders, carnivores and carrion-eaters (Savilov, 1957). The bottom topography is complex due to the variety of bottom soil, and the complicated system of water circulation and temperature changes. A certain vertical zonation is observed in the distribution of the biota. Rock soils in the coastal areas are occupied predominantly by a fouling fauna. With the increase in depth the fauna is replaced by mobile sestonophages, and there is a wide zone with a predominance of detritus-collecting forms extending adjacent to it. Mollusca are replaced by Ophiura, and finally in the deep water the Polychaeta acquire a dominant role. In the central deep water sessile sestonophages of soft soils become intensely developed. The densest benthos colonies are found off the northern and eastern shores of the sea with a predominance of fouling fauna where the total biomass is frequently of the order of 1 kg/m^2. In the deep trench in the central part, the benthos biomass is as low as 10 mg/m^2. Out of the total benthos biomass (about 300 million tons), Mollusca are most important (about 30 percent), Echinodermata comes second (about 25 percent) and Polychaeta third (about 12 percent). Details of benthic biomass on the continental shelf are summarized well by Moiseev (1953, 1955, 1971). The largest biomass per square metre is found along the northern and southern coasts of the West Kamchatka where it is about 350-680 g/m^2. Benthic biomass decreases towards the west to 50-150 g/m^2 along the northeastern coast of Sakhalin and then increases southward to the second largest biomass of about 370-550 g/m^2 in Terpeniya and Aniva Bays.

In the Japan Sea about 380 species of bottom-living macrophytes have been listed (Zenkevich, 1963). Along the USSR coast, Arctic-boreal species are predominant in the northern part and boreal ones in the southern part. Vast fields of the commercially-utilized marine grass Phyllospadix occur at 0.5 to 15 m depth in some areas of the southern USSR coast with an average biomass of 2-5 kg/m^2 in wet weight. The bottom fauna has been well studied in Peter the Great Bay, where the fauna is much more abundant on the soft sediments than on the rock in the littoral zone. In the sublittoral zone, fields of the sea grass Zostera provide shelter to an abundant fauna. Somewhat deeper in the Laminaria and red algae zone, Polychaeta make up half of the benthic biomass. On a sandy silty sediment the second and third in importance are Echinodermata and Mollusca, while on sand, Crustacea make up 70-95 percent of the biomass. At greater depths (80-200 m) the total biomass becomes noticeably reduced and deeper still it is even poorer. It is a feature of the Japan Sea, in comparison with the neighbouring Okhotsk Sea, that the bottom fauna becomes markedly poorer in species composition with increasing depth. In the Japan Sea, the biomass also decreases noticeably as the depth increases (Zenkevich, 1963). The biomass on the shelf along the west coast is relatively low with about 94 to 340 g/m^2, whilst the greatest biomass is found in Peter the Great Bay at 50 to 80 m depths (Moiseev, 1955).

Around the Japanese Islands, the bottom flora comprises about 860 species, of which 310 species are endemic to the region. Arctic-boreal or boreal species are distributed around Hokkaido. Subtropical forms prevail along the southern coasts of Japan. In general, the nature of the bottom fauna depends on various local conditions. For example, Porifera and Coelenterata are abundant

along the southern coasts of Japan through West Kyushu into the Korea Strait and further north again towards the Tsugaru Strait along the coast of the Japan Sea. Annelida are widely distributed with a predominance of sedentary forms. Crustacea, mostly Decapods, are also widely distributed. Echinodermata, Asterioidea, Echinoidea and Holothurioidea are dominant on sandy beds along the Pacific coasts. In warm waters Ophiuroidea is more abundantly distributed farther offshore on the Japan Sea side, although it is found also in muddy regions in the Pacific side. Mollusca are rather more abundant and are distributed offshore in the southern part of the Japan Sea. A eutrophic region lies west of Kyushu in the Korea Strait and extends over the shelf of the southern Japan Sea. Another eutrophic region is present near the Tsugaru Strait although this is narrow. The detailed survey of the benthos around Japan has been rather limited to a few specific bays and inlets (Horikoshi, 1962a, 1970, Yokoyama, 1980). The average biomass of benthos on the continental shelves along the Pacific coast of Japan appears to be moderate with a range of about 15-72 g/m^2. An exception is the shallower part of Tokyo Bay where an average of about 200 g/m^2 and a maximum of about 1,200 g/m^2 were observed (Horikoshi, 1962a, 1970). It should be noted that these figures are not necessarily comparable with those obtained by the USSR scientists in the Okhotsk and Japan Seas because details of the sampling instruments and sieves and the size of exclusion of the larger animals are quite different for the two areas. The biomass generally decreases sharply with increasing depth. It appears that the shallower waters of the shelf exhibit about an order of magnitude more, and the shelf edge an order of magnitude less biomass on the average (Horikoshi, 1970).

In the Yellow Sea and in the East China Sea the dominant benthos groups are very similar to those along the southwestern coast of Japan. For example, Holothuridae, Macrura, Brachyura and Cephalopoda are abundant in the central part of the East China Sea; Ophiuroidea are abundant in the northern part; Macrura, Ophiuroidea, Brachyura and Asteroidea are abundant in the southern part. Ophiuroidea are distributed in depths between 60 to 85 m. Asteroidea in 50 to 80 m and 100 to 150 m, Macrura in 50 to 110 m, Gastropoda and Cephalopoda in about 50 m. In general the highest densities are found at a depth of about 70 m. In general, the biomass of benthos in the region appears to be extremely small, averaging about 10-30 g/m^2 (Horikoshi, 1970, Moiseev, 1971). It should be noted that both the Japanese and Russian surveys reported a low abundance in this region. In the northern region however, their survey methods might have differed substantially from each other and this might have caused large differences between their respective estimates. Further detailed studies are required in the future in the Yellow and East China Seas especially in connection with the large biomass of demersal fish resources there.

6. FISHERIES

6.1 Statistics

The fishery statistics for the area are reported differently by different countries. For instance even the total catch is not available for the Democratic People's Republic of Korea (Korea D.P. Rep.). For a few countries the species breakdown of the catch is incomplete and the accuracy of the catches is not high. For the others, more reliable statistics are available. Except for a few fisheries in Japan and the Republic of Korea (Korea Rep.) there is no information on fishing effort, where there are nominal figures for effort, these are generally inappropriate for assessment purposes as no account is taken of the changes in gear efficiency over the years. Catches by Viet Nam, along the northern coast of the country including the Gulf of Tong King, are excluded from this study as no information is available. (Figure 1).

The catch statistics for Japan and Korea Rep. provide details of catch composition and method of fishing. It is sometimes difficult, however, to allocate catches to sub-areas (or Seas) because the statistics are compiled on the basis of landing locations and not fishing locations. For the USSR statistics are available only for total catches from the entire region for selected species. The statistics from the People's Republic of China (China), though they have been greatly improved since 1970, are still incomplete in terms of species breakdown, method of capture and fishing area. For instance, only 7 species (4 demersal and 3 pelagic) have been treated separately. The species composition of the catch for Macau, Portugal is also not known.

The details of catches[1/] and productions,[2/] broken down by sub-area referrred to in this report have been estimated mostly by the author based on the detailed national statistics and other relevant information. For example, the total marine fish catches by Korea D.P. Rep. were sub-divided into the Japan Sea and Yellow Sea based mostly on the information obtained by a FAO Mission.[3/] They

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1/ So called "catches", but excluding marine mammals and seaweeds.
2/ Catches plus aquaculture production without feeding (shellfish and seaweeds).
3/ Back-to-Office Report, Travel to Korea D.P. Rep. and China, 28 August - 25 September 1980 prepared by D.D. Tapiador

were not broken down into either species or species groups. The catches in the outermost two sub-areas, the Western Bering Sea and the Northwestern South China Sea could not to be separated. The catches from these regions have therefore had to be combined with those from neighbouring inner sub-areas, i.e. with the Pacific Ocean and the Yellow Sea to East China Sea respectively.

Subdivision into fish groups has been based on the behaviour of the fish and characteristics of the catch rather than on a taxonomic basis. For example, largehead hairtail is here classified as a demersal fish whilst chub mackerel and Japanese Spanish mackerel are classed as coastal pelagic fish. It should be noted that the catches of some species and species groups are apt to be underestimated due to the incompleteness in the species breakdown in the national statistics. Because of this, the catch of "Other fishes" is unavoidably overestimated. The catches of certain species groups such as cephalopods, crustacea and shellfish are also generally underestimated due to the incompleteness of the national statistics.

6.2 Fisheries

6.2.1 Total catch

Catches for the entire area for 1970 to 81 are given by country and species group in Tables 4 and 5 and in Figure 3. In the same tables the total production by sub-area is also given by country and species group for 1979. The total catch has exhibited a slow but steady increase during the past decade and has approached 19.8 million tons in 1981, a value which is about 1.6 times the catch in 1970. The catch from the area has been the largest among the fishing areas in the entire world, and in 1981 it accounted for about 29 percent out of the entire world production of 66.8 million tons. The catch for the second most important area, the Northeast Atlantic, was about 11.6 million tons making up 17 percent of the world total (Table 13).

The Japanese catch is particularly important in the Northwest Pacific accounting for 45-55 percent of the total, followed by the USSR which made up 12-18 percent and China which made up 16-18 percent. The catch by both the Korea Rep. and Korea D.P. Rep. has been moderate at 6-9 percent for each country. The remainder, due to Hong Kong, Macau and Taiwan, Province of China has usually made up less than 5 percent of the total. A steady increase in total catch was realized by most of the countries in the region except for China and Macau for which there has been no clear trend since 1977. It is interesting to note that the recent increase in the total catch in the two major fishing countries, the USSR and Japan has been due to different species, namely Alaska pollack in the former and Japanese sardine in the latter.

A general increase has been shown by fish, crustacea and shellfish whereas the catch of cephalopod has shown no significant trend throughout the years (Table 5-(1)). All the fish species groups showed an increase in the catch by 1.5-2.0-fold during the past ten years. However, the increase in demersal fish catch occurred during the early 1970's since when it has remained at nearly the same level or even declined (Table 5-(1) and Figure 3). The pelagic fish catch on the other hand shows a large increase in the later half of the 1970's due to the recovery of the Japanese sardine.

By sub-area, the largest catches came from the Yellow Sea to East China Sea followed by the Bering Sea to the Pacific Ocean[1/], the Okhotsk Sea and finally by the least in the Japan Sea, (Table 5-(2)). It should be noted that the order of importance by catch is not the same as the order of importance by productivity, as was briefly discussed in the section on primary production. As far as fish catches in coastal waters is concerned, the Bering Sea to the Pacific Ocean[1/] has been most important followed by the Japan Sea, the Okhotsk Sea and finally by the Yellow Sea to East China Sea (Table 3). Catches by country clearly depend on the importance of the adjacent sea areas (Table 4-(2)).

Regarding species groups, (Table 5-(3)), the Bering Sea to the Pacific Ocean is characterized by a predominance of pelagic fish. The Okhotsk Sea is characterized by demersal fish. The Yellow Sea to the East China Sea is characterized by demersal and pelagic fish in equal proportions. However, demersal fish would probably be more important, if the largely unspecified Chinese catch, which probably consists mainly of demersal fish, could be taken into account. In the Japan Sea, even though the catches by the Korea D.P. Rep. and the USSR are not known, pelagic fish catches exceed those of demersal fish and this is consistent with the very narrow and limited continental shelf area (Table 1).

1/ The catches were taken mostly from the waters along the Pacific coast of Japan.

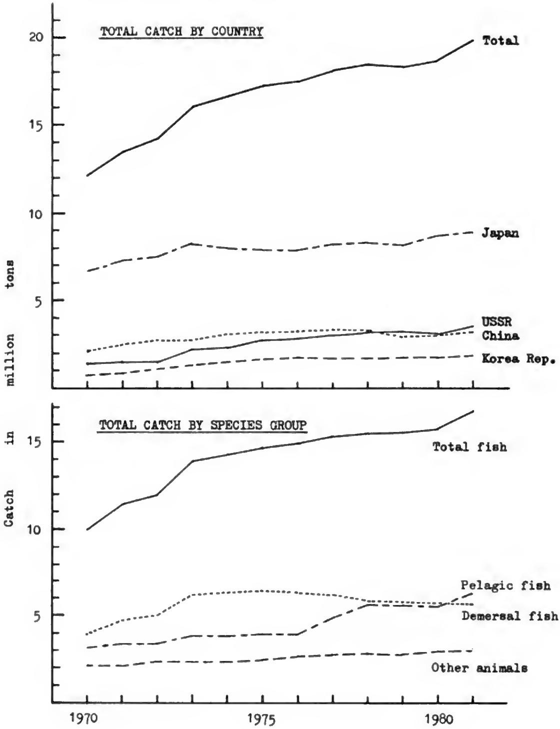

Figure 3. Total catch by country and by species group during 1970-81. See Tables 4(1) and 5(1) for statistics.

Table 4

Total catch and total production by country.

(1) Total catch[1] by country during 1970-81

('000 t)

Country	1970	1975	1976	1977	1978	1979	1980	1981
Japan	6,650	7,898	7,916	8,206	8,382	8,157	8,637	8,847
USSR	1,448	2,719	2,752	2,943	3,003	3,268	3,196	3,553
China	2,193	3,182	3,264	3,387	3,335	2,938	2,995	3,232
Korea Rep	726	1,668	1,747	1,696	1,655	1,763	1,675	1,851
Korea D.P. Rep[2]	447	1,000	1,064	1,130	1,200	1,264	1,330	1,420
Hong Kong	133	147	153	154	157	183	188	176
Macau	10	10	10	4	7	6	7	8
Others[3]	498	629	652	677	701	731	731	728
Total	12,103	17,253	17,558	18,198	18,440	18,310	18,759	19,814

(2) Total production[4] by country and sub-area[5] in 1979

Country	Sub-area				
	Bering Sea Pacific Ocean	Okhotsk Sea	Japan Sea	Yellow Sea E. China Sea	Total
Japan	5,073	646	1,402	1,510	8,631
USSR	652	2,615[6]	?[6]	-	3,268
China	-	-	-	4,482	4,482
Korea Rep.	128	-	246	1,652	2,020
Korea D.P. Rep.[2]	-	-	885[7]	379[7]	1,264
Hong Kong	-	-	-	183	183
Macau	-	-	-	6	6
Others	-	-	-	743	743
Total	5,843	3,261	2,533	8,955	20,597

1/ Excluding marine mammals and seaweeds.
2/ Estimated by FAO, but refers only to the total catch of marine fishes.
3/ Almost exclusively Taiwan, Province of China, although a very small catch (less than half a ton) has been reported from Midway Islands, U.S.A.
4/ Includes seaweeds and aquaculture products without feeding.
5/ See text for the definition and problems involved.
6/ Unable to separate from Okhotsk Sea.
7/ Estimated by the author based on the FAO Mission Report.

Table 5

Total catch[1/] and total production[2/] by species group.

(1) Total catch by species group during 1970-81.

('000 t)

Species group		1970	1975	1976	1977	1978	1979	1980	1981
Fish	Salmon	161	262	197	248	182	262	222	251
	Demersal fish	3,936	6,427	6,261	6,184	5,828	5,733	5,684	5,630
	Pelagic fish 2/	3,173	3,968	3,920	4,829	5,617	5,608	5,544	6,208
	Tunas	364	366	448	400	458	462	488	457
	Other fishes 3/	2,369	3,664	4,035	3,713	3,449	3,770	3,770	4,252
	Sub-Total	10,003	14,687	14,861	15,374	15,534	15,476	15,708	16,798
Other Animals	Cephalopod	687	639	656	611	670	738	885	685
	Crustacea	531	695	675	717	817	713	741	816
	Shellfish	717	1,131	1,291	1,408	1,344	1,283	1,339	1,427
	Others	165	98	75	87	78	97	86	88
	Sub-Total	2,100	2,563	2,697	2,823	2,909	2,831	3,051	3,016
Total		12,103	17,250	17,558	18,197	18,443	18,307	18,759	19,814

(2) Total production[1/] by species group and sub-area[4/] in 1979

('000 t)

Species group	Sub-area				
	Bering Sea Pacific Ocean	Okhotsk Sea	Japan Sea	Yellow Sea E. China Sea	Total
Fish	4,659	3,116	2,219	5,319	15,313
Other animals	695	138	279	1,717	2,829
Seaweeds	495	7	35	1,919	2,455
Total	5,848	3,261	2,533	8,955	20,597

(3) Total fish production[1/] by species group and sub-area[4/] in 1979.

('000 t)

Species group	Sub-area				
	Bering Sea Pacific Ocean	Okhotsk Sea	Japan Sea	Yellow Sea E. China Sea	Total
Salmon	98	154	9	-	261
Demersal fish[5/]	1,038	2,681	496	1,509	5,723
Pelagic fish[6/]	3,031	95	771	1,567	5,465
Tunas	318	-	3	142	463
Other fishes	173	186	941[7/]	2,100[7/][8/]	3,400
Total	4,659	3,116	2,219	5,318	15,313

1/ See Table 4 for the definition of catch and production.
2/ Including tuna-like fishes such as king mackerel, marlin and swordfish.
3/ Total fish catch by Korea D.P. Rep. and about 50 percent of the catch by China are included.
4/ See text and Table 4 for the definition and problems involved.
5/ Excluding cultured silver seabream.
6/ Excluding cultured Japanese amberjack.
7/ Total fish catch by Korea D.P. Rep. in the sub-area is included (about 0.9 million tons in the Japan Sea and 0.4 million tons in the Yellow Sea).
8/ About 50 percent of the Chinese catch is included (about 1.2 million tons).

It can be noted, in this connection that in the Pacific Ocean, where the shelf area is smaller than in the Japan Sea (Table 1) there is a substantially larger catch of demersal fish than in the Japan Sea (Table 5-(3)). The majority of the catch comprises Alaska pollack (43 percent), flatfishes (9 percent), sandlance (7 percent) and a few other commercially important species (11 percent) from the entire Pacific coast of Japan which clearly shows higher productivity of the continental shelf, though the extent of the shelf is narrower along the coast.

6.2.2 Fisheries jurisdiction and international agreements

Four nations out of eight have extended their national jurisdiction on fishing to 200 miles offshore since 1977. These are Japan, Korea D.P. Rep., U.S.A. and USSR.[1/] However, the Japanese jurisdiction has not been applied to the Chinese and Korean (Rep.) fisheries as the governments of those countries have not yet extended national jurisdictions along their coasts. Hong Kong (U.K.) and Macau (Portugal) have also not extended their national jurisdiction as of the end of 1983, while the United Kingdom and Portugal have already extended their jurisdiction along the mainland coasts since 1977.

The Indo-Pacific Fishery Commission (IPFC) and the International North Pacific Fisheries Commission (INPFC) are existing multi-national bodies that collaborate in scientific research and in fisheries management and development. IPFC, one of the FAO regional bodies on fisheries, is supported by a large number of nations and covers a wide area, including the Northwest Pacific, and other areas. However, in the Northwest Pacific its activities in the past have scarcely been directed as the status of the fisheries there are somewhat apart from the main concerns of the Commission.

1/ The USSR Government proclaimed the extension of the jurisdiction in December 1976 but was carried into effect on 1 March 1977.

INPFC was established by Canada, Japan and the U.S.A. originally to deal with the management of commercially-important resources in the northern North Pacific. However, the terms of reference of the Commission have been limited to international collaboration on scientific research and a study of the commercially-important resources in the Convention area since 1978 (INPFC, 1980, 1980a). This was in conjunction with the extension of fishing jurisdiction by the two coastal countries, Canada and the U.S.A. The management of the resources has been the responsibility of the coastal states, which defines many regulatory measures by bilateral agreements with the countries concerned. The linkage of INPFC with this particular area is rather minor, since the Commission is mainly concerned with the resources which inhabit, or originate from, mainly Canadian or American waters.

There are a number of bilateral agreements being currently enforced in the area. There are three Conventions[1/] between Japan and the USSR including regulation of the Japanese salmon fishing on the high seas, demersal and pelagic fishing by each nation in the Okhotsk Sea, northern Japan Sea and along the northern to central Pacific coast of Japan. The catch quotas by species, the regulations on fishing ground and season have been imposed on the various fisheries. Agreements between Japan and the Korea Rep. and between Japan and China define the joint regulatory areas for trawling, purse-seining and line fishing in the Yellow Sea and the East China Sea. The fishing effort on these fisheries is limited. The size of mesh permitted for trawl nets has been regulated to be larger than 54 mm, while prevention from catching juvenile fish is strictly defined in the agreement between China and Japan. A bilateral agreement between Japan and the U.S.A. regulates Japanese demersal fishing in the jurisdictional waters of the U.S.A. These include the American waters in the western Bering Sea and around Midway Island in an area where strict catch quotas by major species and species groups are imposed. Fishing grounds and seasons are also defined. There is a similar convention between the Korea Rep. and the U.S.A.

Each of the above-mentioned conventions holds an annual meeting every year to review management measures for the coming fishing season. This is usually preceded by a meeting of a scientific sub-committee composed of the scientists from both parties. However, details of the discussions and the results obtained at these scientific sub-committee meetings have never been made public.

A non-governmental fisheries agreement was established in 1977 between Japan and the Korea D.P. Rep. to regulate Japanese fishing for salmon, crabs and squids in Korean D.P. Rep. waters in the Japan Sea. This agreement was effectively enforced until 1982, but on a non-governmental basis since no diplomatic relationships have been established so far between the two nations. Since 1982, the agreement has not been renewed because of political differences between the two governments. It is not known whether the Korea D.P. Rep. has established an agreement on fisheries with China or the USSR.

6.2.3 Japan

The total annual catch of the Japanese fishery from the Northwest Pacific has continued to increase even in recent years and reached about 8.8 million tons in 1981. This represents an increase of about 33 percent during the past decade (Table 4-(1), Figure 3). This catch is the highest for the various countries in the area and accounts for about 44 percent of the total catch. It is also the highest catch in the world accounting for about 13 percent of the total world catch of 66.8 million tons in 1981. The increase in recent years was due to an extremely large increase in the catch of Japanese sardine. Sardine stocks around Japan have increased since the mid-1970's, and this has compensated for the sharp decline in the catches of Alaska pollack, Jack mackerel and chub-mackerel during the same period. The decrease in the Japanese catch of Alaska pollack since 1974 was not due to a decline in the stock of this species. It was a consequence of a substantial reduction in fishing operations in the Okhotsk Sea and western Bering Sea in connection with the extension of the jurisdictional powers of the coastal states beyond their territorial waters. Other notable features of the recent Japanese catch are rapid and remarkable increases in the coastal catch of chum salmon and in the offshore catch of oceanic squids. These increases are attributable to the development of new technology in re-stocking for the first and in fishing for the latter.

1/ (1) Japan-USSR Fisheries Cooperation Convention: defines mostly the regulatory measures on the Japanese salmon fishery on the high seas.
(2) Japan-USSR Fisheries Convention: defines the regulatory measures on the Japanese fisheries in the jurisdictional waters of the USSR.
(3) USSR-Japan Fisheries Convention: defines the regulatory measures on the USSR fisheries in the jurisdictional waters of Japan.

The greater part of the Japanese catch is taken from the waters along the Pacific coast of Japan (Table 4-(2)). The catch is the least from the Okhotsk Sea where fishing has been completely controlled by USSR jurisdiction. As was mentioned in the previous sub-section, Japanese fishing in parts of the Yellow Sea and East China Sea is subject to regulations determined by bilateral agreements between China and between the Korean Rep. Fishing effort in the Japanese offshore trawl fisheries[1/] in the region has been declining since the late 1960's. This is partly due to lower catch rates which have resulted from a decline in stock abundance and which will be discussed in a later section. It is also due to higher fuel and labour costs and also to difficulties in fishing as a consequence of stringent regulations imposed by the bilateral agreements. The number of vessels in the coastal and offshore pole-and-line skipjack fishery has also declined due to a considerable decline in commercial profitability since the late 1970's. This was mainly due to higher fuel and labour costs and also to a drop in the market price of skipjack. Some fishing rights have been transferred to the purse-seine skipjack fishery.

Fishing efficiency appears to have improved in almost all fisheries during the past decade. This is particularly the case for coastal purse-seiners and other small vessels due to the mechanization and modernization of the vessels, including gears and equipment. The total fishing effort in the waters around Japan has, therefore, probably increased considerably during the period.

Fisheries management in Japan after World War II has developed well and in a highly sophisticated way. Regulation of total fishing effort is through a strict licensing system, implemented both by central and local governments. This has been fairly successful so far especially for the coastal and offshore waters around Japan (Asada, 1973, Asada et al., 1983). It is noted in this connection that fisheries cooperatives in Japan have played a significantly important role in the implementation of management measures and the coordination among various fisheries and fishermen (Ibid.).

6.2.4 Union of Soviet Socialist Republics

The total annual catch of the Union of Soviet Socialist Republics (USSR) has steadily increased, exceeding slightly that of China since 1979, and reached about 3.6 million tons in 1981. This ranks as the second largest catch in the area and accounts for about 18 percent of the total catch (Table 4-(1)). A feature of the USSR catch is the rapid and continuous increase in the catch of Alaska pollack in the Okhotsk Sea, largely due to a takeover of fishing from the Japanese and Korean Rep. fishery. Another feature is the increase in the coastal catch of pink salmon in recent years, which indicates the recovery of stock abundance from a very low level during the early 1960s. By contrast, there has been a dramatic decline in the catch of Pacific herring from the major fishing grounds. Commercial fishing has been banned from there in turn since the late 1960's - mid 1970's but so far, no sign of recovery has been observed.

As a result of a reciprocal agreement, the USSR started substantial fishing of Japanese sardine, chub mackerel and other species in Japanese jurisdictional waters in 1978. Catch quotas for each of these species is defined at the annual meetings of the USSR-Japan fisheries convention.

6.2.5 People's Republic of China

The total annual catch of the People's Republic of China (China) has shown no marked trend since 1975. The catch is about 3-3.3 million tons (Table 4-(1), Figure 3) which is almost the same as the recent catch by the USSR. Although Chinese catches have been recorded as coming from the southernmost sub-area, "Yellow Sea and East China Sea" in this paper (Table 4-(2)), some of them were actually taken from the northwestern part of the South China Sea, along the coasts of the southern Fujian and the Guangdong Provinces, including the Hainan Island. It is estimated that about 20-25 percent of the total catch is taken from the South China Sea region (Zhu, 1980).

Major species taken are large and small yellow croakers, largehead hairtail, filefish, Pacific herring, chub mackerel, Japanese Spanish mackerel, and fleshy prawn. Details of the catches of other species are not clear as the statistics are not available, but a relatively large number of fish species are commercially exploited, namely about 200 in the Yellow Sea, 440 in the East China Sea and 860 in the South China Sea (Zhu, 1980).

1/ "ISEI SOKOBIKI GYOGYO" : both otter and pair-trawlers exclusively operating in the Yellow Sea and East China Sea (west of 128^{o}E).

The major fishing gears employed are trawl, purse-seine with and without lights, drift and set gill-net, hook and line and trap. Of these, trawling is most commonly carried out in all regions. The motorized fishing fleets are categorized into two groups. These are: (1) small and mostly wooden-made vessels usually less than 30 GRT and 60 HP and (2) large mechanized vessels larger than 100 GRT and 200 HP. The total number of motorized vessels was about 39,000 in 1978 (Zhu, 1980). The smaller vessels predominate numerically and account for most of the total catch. These usually belong to people's communes and engage in various kinds of fishing. The larger vessels usually belong to the industrialized marine fishing corporation[1/] and are employed mostly in trawling and purse-seining. The modernization of these vessels in terms of higher fishing efficiency and better preservation of the catches, appears to have been greatly improved in recent years[2/] though details on the statistics are not available.

A notable feature of recent Chinese catches is the decline in the catches of the principal demersal fish in the Yellow Sea and East China Sea and their replacement by significant increases in the catches of hairtail, large yellow croaker and filefish (Zhu, 1980). However, details are lacking due to the incompleteness of the available statistics. Other features are a substantial increase in the catch of Japanese Spanish mackerel, a sharp decline in the catch of Pacific herring in the Yellow Sea and the continuous high level of the catch of fleshy prawn since 1977. Each of these features will be discussed in detail in the following sections.

6.2.6 Republic of Korea

The total catch of the Republic of Korea (Korea Rep.) has increased during the past decade, attaining its highest value in 1981 at about 1.9 million tons. This is about 2.5 times that of the value in 1970 (Table 4-(1), Figure 3). Most of the catch (82 percent) is taken from the Yellow Sea and East China Sea including the Korea Strait (Table 4-(2)). Catches taken from the Japan Sea are limited to a few species including Alaska pollack, saury, anchovy and Japanese flying squid. This can be associated with the low productivity there in comparison with the region to the south and west of the peninsula.

A notable feature of recent catches is the sudden increase and the decrease of Alaska pollack during the 1970's. The increase was due mainly to the expansion of the long-range trawl fishery in the waters off southern Kamchatka to the northern Kuril Islands in 1971 (Lim et al., 1978). It was also partly due to an increase in the catch of small (young) Alaska pollack by the coastal fishery in the Japan Sea since the early 1970s (Kang et al., 1982). The subsequent decrease was due to the withdrawal of long-range trawlers from USSR waters in connection with the extension of the USSR jurisdiction there. A few of these long-range trawlers have been operating in Japanese waters along the northern Pacific coast of Japan in recent years (Table 4-(2)). Catches of many other fish species have increased, namely filefish since 1975, hairtail since around 1970, Japanese sardine since 1975, Japanese anchovy since 1972 and Japanese Spanish mackerel since the early 1970s. Each of these will be discussed in detail in the following sections. A particular feature of the Korean Rep. catch is that the catch of demersal fish in the Yellow Sea and the East China Sea has shown a continuous increasing trend during the past 15 years and this contrasts with the decline in the catches by China and Japan. This is due to the continuous increase in the fishing efficiency of the Korean Rep. trawlers. It could not have been due to an increase in stocks, since assessments made by Korean scientists concluded that the stocks were generally overexploited, even, by 1975 and recommended a reduction of fishing effort (Hwang, 1977). Fishing efficiency appears to have been improved a great deal not only in the trawl fishery but also in many other fisheries such as purse-seine, drag net, gillnet and even in the stationary stow-net fishery,[3/]. This will be discussed further in later sections.

1/ State-owned, usually entrusted its operation and management to a local government (city or province).

2/ Source: many anonymous articles in the series of "Marine Fisheries", published by the Society of Fisheries, China during 1980-82.

3/ A stow-net is a streamer-type set-net used to catch animals where there are tidal currents (Han et al., 1980, 1981 Fish.Res.Dev.Agency,Korea Rep., 1970). The size of the net is greatly variable. It may be 20-30 m in length with a 5 m opening held open by a frame or beam. It may be as large as 100-150 m in length with a 30-40 m opening held open by floats and sinkers. The mesh size can also be variable with 17-40 mm at the codend. However meshes are mostly small and the effective size is sometimes less than 10 mm. The net is set at both the bottom and at the surface of the sea in coastal waters. Fishing by stow-net is quite popular in China too for catching jellyfish (Zhu, 1980).

6.2.7 Democratic People's Republic of Korea

Information on the fisheries in the Democratic People's Republic of Korea (Korea D.P. Rep.) is very sparse. Even the total catch, which refers only to the total catch of all species combined has had to be estimated by FAO by extrapolating from the estimated catch in earlier years (Table 4-(1)). The report of an FAO Mission which visited Korea D.P. Rep. in 1980 provides the only information about the subject (see footnote in section 6.1). The separation of the total catch by area into the Japan Sea (east coast) and Yellow Sea (west coast) was made by the author based on the information presented by the Mission (Table 4-(2)).

An outline of the fishery can be summarized as follows: several major fishing ports are located along both the east and west coasts; Wonsan, Sinpo and Soho along the former, Nampo, Sinuiju and Haeju along the latter. The east coast is more productive than the west in terms of the total catch and variety of species taken, accounting for about 60-80 percent of the total production and comprising both cold and warm water species such as pollack, plaice, squid, cuttlefish, flatfish, sandfish, saury, herring, salmon, sardine, mackerel, anchovy and yellowtail. Catches along the west coast are rather limited and made up of croakers, hairtail, prawns and shrimps. It is said that about 32,000 fishing vessels were in operation in 1970 and that the total tonnage of fishing vessels has been increasing by about 20,000 t per year. Trawling is the principal fishing method and is performed by mechanized trawlers of various sizes i.e. 270, 450, 1,000, 3,750 tons classes.[1/] Purse-seining with light at night, drift gillnetting and trapping[2/] are additional methods employed along the east coast. Dragnet, driftnet and traps are used along the west coast. The organization of the fishery is not clear. It appears, however, that large mechanized trawlers and purse-seiners are state-owned by fishing enterprises/corporations such as the Wonsan State Fishing Enterprise and the Soho State Fishing Enterprise. The export of fisheries products has been increasing, the major foreign markets being Japan, Hong Kong and Singapore. The total amount exported to Japan in 1981 was about 16,500 t of which about 9,100 t comprised fish (Japan Tariff Association, 1982) and this accounted for about 0.7 percent of the estimated total fish catch. The major products were frozen salmon, herring and cod, salted Alaska pollack roe, frozen crabs, prawn and squid and live hard clam.

6.2.8 Hong Kong

Hong Kong has traditionally been active in fishing and various fish species, including crustacea and cephalopods have been intensively caught. The existence of about 5,000 fishing vessels compared with about 32,000 vessels in Korea D.P Rep. in 1970 (Richards, 1982) illustrates the importance of fishing there. However, the annual catch is small compared with that for other nations in the Northwest Pacific with about 180,000 t. This accounts for about 1 percent of the total catch (Table 4-(1)). This catch is taken mostly from the northern South China Sea (Table 4-(2)) and has shown no significant trend in recent years. It is noted that some of the larger stern-trawlers extend their operations to the southern East China Sea (Richards, 1982).

The principal fishing gears employed are: various types of trawl (pair, stern, beam and hang), longline, handline, gillnet and purse-seine. Pair and stern trawlers are most important and account for about 60 percent of the total catch. These are followed in order of importance by gillnet (14 percent) and longline (8 percent). Trawling is usually non-directed and the catch consists of various fish species. Squids are intensively caught by trawlers during summer to autumn and shrimps are also taken by beam trawlers. The fishing efficiency of the trawlers seems to have been improved substantially in recent years judging by the change in the vessel numbers by type of trawler, i.e. stern trawlers have increased; from 160 to 447, modern pair trawlers have increased; from 114 to 231. Junk trawlers on the other hand have decreased; from 231 to 125 from 1975 to 1980. In addition to the mechanization of the vessels there has been an increase in the average engine power during the past 20 years, from about 30-40 HP to 200 HP (Gaiger et al., 1980). It should be noted, however, that the catch per unit effort of the trawl fishery (per headline length, engine power and day) has decreased substantially in recent years (Richards, 1982).

Another feature of the Hong Kong fishery is the recent decline in the purse-seine fishery. Although this fishery is of minor importance in Hong Kong, both the number of mechanized purse-

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1/ The fishing grounds are not clear, especially those for the larger vessels. It is noteworthy however that smaller vessels (e.g. 450 tons class), including purse-seiners with lights and gillnetters, appear to be multi-purpose fishing boats.

2/ Probably including stow-nets.

seiners and their catch has decreased substantially probably due to economic fishing (Chung et al., 1980). The catch consists mostly of small pelagic fish such as round scads, Sardinella spp., shads and anchovies. These are of very low commercial value in the Hong Kong market, and are usually of less than half to one-third of the value of the fish taken by other gears. In recent years the greater portion of these landings has been used as feed for aquaculture.

6.2.9 Macau

The total catch by Macau, has been relatively small and stable throughout the years. The recent annual catch is about 6-8,000 t which accounts for only 0.05 percent of the total catch (Table 4-(1)). Much attention has not been paid therefore to the exploitation by the Macau fishery. A unique nature of this fishery appears to be that the reported catch of crustacea is usually greater than that of fish, making up about 60 percent of the total, however, details on this are not known.

6.2.10 Other fisheries

The other fisheries in the area are those of Taiwan, Province of China and Midway, (U.S.A.). The Taiwanese fishery has been quite significant while that of Midway has been less than half a ton per year.[1/]

The total catch of the Taiwanese fishery has increased by about 50 percent during the past 10 years but has been relatively stable in recent years at about a level of 180,000 t. It accounts for about 1 percent of the total catch in the area (Table 4-(1)). The principal fishing methods employed are: pair trawl, otter trawl, drag net (shrimp trawl), tuna longline, torch light net, purse-seine, bottom longline and gillnet.[2/] The most important fishing is by trawlers and dragnet vessels which achieve the largest catch and these operate widely on the continental shelf area along the mainland coast from the northern East China Sea in the north, to the Gulf of Tonkin in the south and including the Formosa Strait (Liu et al., 1979). Major fish groups taken by trawlers are hairtail, lizard fish, daggertooth pike conger, crabs, cuttlefishes, white croaker and shrimps. The torch light net, purse-seine and beach seine are the next most important gears and these operate mostly in the waters around the Formosa Island to catch small pelagic fish such as round herring and anchovies (Shen, 1971). The mechanization of these vessels was greatly achieved during the 1960s (Shen, 1971). The improvement in fishing efficiency due to the mechanization and modernization of the vessels and equipment appears to have been happening continuously.

Taiwanese offshore tuna longliners of less than 50 tons catch substantial amounts of yellowfin and bigeye tunas as is the case with the Japanese tuna fishery. Another tuna fishing nation in the area, Korea Rep. takes only moderate quantities of tunas.

7. STOCK ASSESSMENT

The major resources to be dealt with in this paper are divided into six species groups, namely salmon, demersal fish, coastal pelagic fish, skipjack and tunas, squids and shrimps. This grouping is mainly due the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP). However, some modifications were applied. For example, hairtails, Trichiuridae and mackerels, Scombrini are here classed as demersal and pelagic fish respectively to be more consistent with the catches by different kinds of fishing gear.

As mentioned previously, the catch statistics for many species referred to in each section are underestimated due to the incomplete statistics from several nations. Some details are shown in the footnotes to the tables.

7.1 Salmons

There are six commercially important species in the area, pink salmon, *Oncorhynchus gorbuscha*, chum salmon, *O. keta*, sockeye salmon, *O. nerka*, chinook salmon, *O. tshawytscha*, coho salmon, *O. kisutch* and cherry salmon *O. masou* (Table 6 and Figure 4). These are anadromous fish ending their life just after spawning in their natal rivers. The spawning rivers of the first four species referred to above are widely distributed along the northern coasts of Asia and North America. The

1/ FAO statistics.
2/ Provincial statistics.

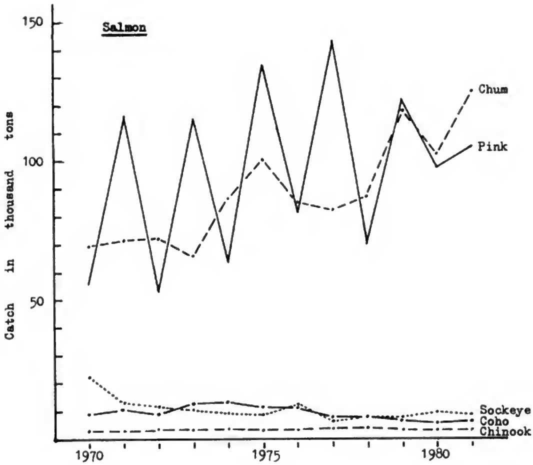


Figure 4. Catch of salmon during 1970-81. See Table 6 for statistics.

Table 6

Catch of salmon by species during 1970-81[1/].

('000 t)

Species	1970	1975	1976	1977	1978	1979	1980	1981
Pink salmon	56.0	134.1	83.2	142.6	70.5	121.7	97.4	105.0
Chum salmon	69.1	100.6	84.8	83.1	86.8	118.5	102.3	125.3
Sockeye salmon	22.6	9.1	10.0	6.4	8.6	8.3	9.8	8.9
Coho salmon	9.9	11.5	11.3	7.8	8.1	6.8	6.1	6.9
Chinook salmon	3.0	3.3	3.6	4.0	4.0	3.6	3.5	2.8
Cherry salmon [2/]	?	3.8	3.7	3.7	3.5	2.6	2.7	2.6
Total	16.06	262.4	196.6	247.6	181.5	261.5	221.8	251.4

1/ Mostly exploited by the USSR and Japan, no information is available for the Korea D.P. Rep.
2/ Catch by the USSR is not known and excluded.

coastal distribution of these species is therefore widely spread out along the coasts of northern Japan, USSR, Alaska, Canada and Washington to Oregon State of the U.S.A. The offshore distribution extends over a vast area of the northern North Pacific including the northern Japan Sea, the Bering Sea and the southern Arctic Ocean (Takagi et al., 1981, Neave et al., 1976, French et al., 1976, Major et al., 1978, Godfrey et al., 1975). Salmon originating from both the Asian and American continents considerably overlap their habitats during their oceanic-life stage especially in the central part of the northern North Pacific and Bering Sea (Harrt, 1966). The spawning rivers and offshore distribution of cherry salmon, on the other hand, are limited to along the Asian continent (Kubo, 1980). Catches of this species are confined within coastal and offshore waters and are therefore not subjected to international regulations. The durations of the fresh-water and oceanic lives of salmon differ greatly from species to species and even between individual specimens. Because of their regular return to the natal rivers, each species consists of too many unit populations to deal with separately. However, it is usual to group geographically nearby populations into a set of local stocks for practical purposes.

In the Northwest Pacific, salmon have traditionally been caught by the USSR and Japan. Chum and pink salmon are most important and have been caught in large amounts throughout the years (Table 6 and Figure 4). Sockeye salmon has also been fished intensively due to its high commercial value, although both the stock size and the catch are moderate. The other three species - chinook, coho and cherry salmon - belong to smaller stocks and have a low commercial value. This is especially so for cherry salmon. In the pre-war period fishing developed mostly along the coast in the vicinity of spawning rivers and offshore fishing was not important. After the war, since losing all its fishing and processing bases along the USSR coast, Japan rapidly developed mothership-type high sea salmon fishing and land-based offshore salmon fishing. The growth of this fishing led to serious problems with the allocation of catches between the offshore/high seas (Japan) and coastal (USSR) fisheries. A bilateral fisheries commission was established by the two nations in 1957 and the Japanese fishery is subject to a catch quota and other regulations issued by the Commission. As was described in the previous section, further regulations have been imposed on the Japanese fishery since 1977 in connection with the extension of national jurisdiction by the USSR government. A scientific meeting has been held every year since 1957 to assess the state of the salmon stocks. However, details of the discussions and the assessments made by the committee have never been made public. The Japanese salmon fisheries since 1977 have also been prohibited from catching salmon in the U.S.A. fishing zone along the Aleutian Islands.

7.1.1 Pink salmon, Oncorhynchus gorbuscha (Walbaum)

Pink salmon in the Northwest Pacific comprise of several stocks which originate from the rivers along the east and west coasts of Kamchatka peninsula, north and west coasts of the Okhotsk Sea, east coast of Sakhalin, east and west coast of the northern Japan Sea, Okhotsk and Pacific coasts of Hokkaido and the Pacific coast of northern Japan (Ishida, 1967, Neave et al., 1967, Takagi et al., 1981, Fukataki et al., 1974). The largest stocks appear to be those originating from the west coast of Kamchatka.

The fish swim from their spawning grounds to the sea immediately after hatching, and spend one and a half years in the ocean. As the fish all mature and return to their natal rivers for spawning at exactly age-2, odd and even-year groups form two different and independent reproductive cycles. The odd-year group constitutes the larger sub-group and the annual catch has shown regular large fluctuations throughout the years (Table 6 and Figure 4). These fish are widely distributed across the ocean during their oceanic-life stage.

The catch by the USSR coastal fisheries, seriously declined during the early 1960's. Since then, there has been a gradual but steady increase since 1965 in the odd-year group and more recently in the even-year group (Figure 5 and Appendix Table 1). The catch in recent years has recovered to nearly the same level experienced during the prosperous period before 1955, with about 100,000 t for the odd-year group and 60,000 t for the even-year group. It is believed therefore that the abundance of both sub-groups has been steadily recovering in recent years and that it will grow to a higher level in the near future. The Japanese catch on the high seas and in offshore waters has been severely restricted since 1977.

7.1.2 Chum salmon, Oncorhychus keta (Walbaum)

Until the late 1970's, the catch of chum salmon had been second in importance out of the catches of salmon. Since then, the catch has substantially increased and in recent years the catch has steadily exceeded that of pink salmon (Table 6 and Figure 4). This is mostly due to the success of a re-stocking programme and will be discussed later.

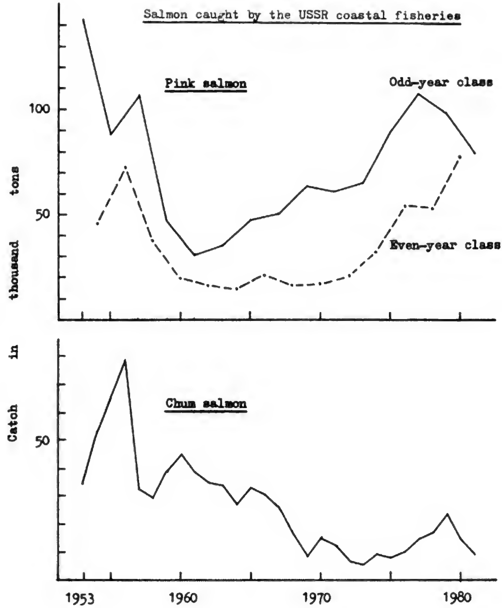


Figure 5. Catch of pink and chum salmon by the USSR coastal fisheries during 1953-81. See Appendix Table 1 for statistics.

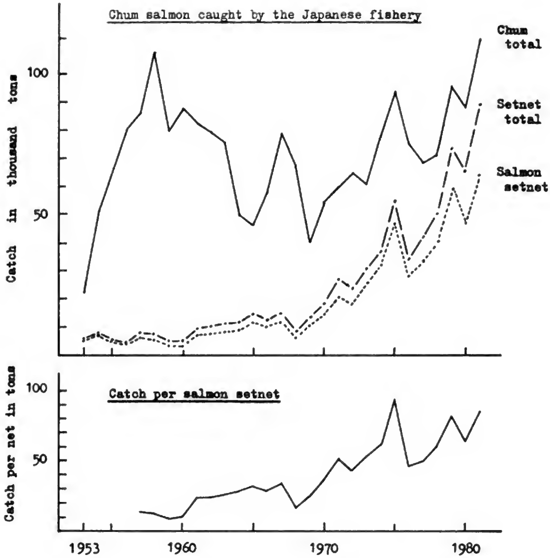


Figure 6. Catch of chum salmon by the Japanese fishery during 1958-81, and the total catches by setnet and salmon setnet fisheries with the changes in the catch per net. See Appendix Table 2 for statistics.

Chum salmon in the area comprises six major local stocks. Those are: East and West Kamchatka, Okhotsk, Amur, Sakhalin and Hokkaido-Honshu of Japan (Sano, 1967, Shepard et al., 1968, Yonemori, 1975). Under natural conditions, the fish swim down river soon after hatching and spend 2-4 years in the sea. Some rearing is also done as part of the artificial re-stocking project. In the sea the fish disperse widely before returning to their natal rivers (Yonemori, 1975, Neave, 1976). The size of naturally spawned stocks appear to have been largest in the case of the Okhotsk stock followed by the Amur and Hokkaido-Honshu stocks during the 1950's to early 1960's. However coastal catches from each stock have fluctuated annually mostly due to fluctuations in the age at which the fish return to the rivers (Sano, 1967). Since about 1975, the abundance of the Hokkaido-Honshu stock exceeded that of the other stocks and in recent years the abundance of both natural and artificially raised individuals appears to have predominated.

The USSR coastal catch declined sharply during the 1960's from about 50,000 t to 10,000 t (Figure 5 and Appendix Table 1). The abundance of the northern stocks may have diminished during the period but it has shown signs of recovery since 1975 (Figure 5).

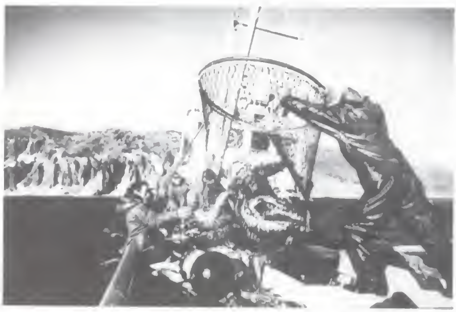
The Japanese coastal catch of chum salmon was at a very low level during the 1950's with an annual catch of about 5-8,000 t. Since 1960 however, the catch began to show a steady increase and this was followed by a larger rate of increase during the 1970's (Figure 6 and Appendix Table 2). The latest catch of the set net fishery in 1981 marked an historical record with a catch of about 90,000 t. This accounts for about 80 percent of the total chum salmon catch by Japan and about 60 percent of the total salmon catch (all species combined) by the Japanese fisheries including offshore and high seas fisheries. Catch and effort data for the Japanese salmon set net fishery clearly show a steady increase in the abundance of chum salmon of Japanese origin since 1960 (Figure 6 and Appendix Table 2). This remarkable increase was due firstly to the long-term activities of salmon hatcheries since the late 1880's and secondly to recent improvements in the technology of artificial breeding and methods of releasing. A substantial increase in the number of fry released has been achieved since 1965 through (1) the expansion of rivers suitable for releasing fry because of the environmental improvements in existing rivers and in rivers where no fish had ascended before, and (2) the construction of new hatcheries and the expansion of old hatcheries (Kaeriyama et al., 1977, Sakano, 1982). At the same time further advanced technology on rearing parental fish and fry and methods of releasing fry has reduced the natural mortality at an early stage of life, especially during the fresh water stage and soon after entering the ocean. This has contributed to a remarkable increase in the ratio of the number of mature fish returning to the rivers, and in the number of fry released (Kaeriyama, 1977, Hashimoto, 1979, 1982, 1982a, Kawamura et al., 1982, Mayama et al., 1982, Sakano, 1982, Igarashi, 1983).

The rearing of fry appears to have played a most important role in the improvement of the rate of return. The fully-ripened eggs and milt are collected from matured fish returning to their natal rivers in northern Japan during mid-September to late December and are artificially fertilized (Hiroi et al., 1973, Hashimoto, 1974). Included in this programme are some fish that are caught in coastal waters near the rivers (Kawamura et al., 1982). The development of the egg needs about two months before hatching although the exact time depends largely on the water temperature. The necessary cumulative temperature time is about 480°C days. After hatching, the larvae mostly inhabit the bottom of the rearing tank for about two months without taking food, while the yolk sac is absorbed. The necessary cumulative temperature time for this period is about 480°C days. The larvae then swim to the upper half of the tank and begin to take food. Artificial feeding with man-made feed starts at this stage and lasts generally for about two months which is a substantially longer than the period employed before 1965 (Hashimoto, 1979, 1982, 1982a). The duration of feeding varies depending on the water temperature (growth of fish) and the timing of their release.

The development of this technology seems to have contributed to an improvement in the rate of survival of released fry, and eventually to the rate of return of adult fish. This is due firstly to a substantial increase in the viability of fry and secondly to the ability of hatcheries to release fry at appropriate times in terms of the appearance of favourable environmental condition in adjacent coastal waters. The rate of return, which had been about 1 percent before 1965, increased markedly with the development of the project and attained 2.66 percent in the case of the 1975 year-class when it returned during 1978-80 (Sakano, 1982, Igarashi, 1983). This development in technology and the enhancement of the stocks has enabled the hatchery to expand further. The number of fry released has been continuously increasing in recent years and now exceeds 1,000 million per year. From these about 28 million adult fish are expected to return annually and this should provide about 100,000 t of harvestable fish.

A good catch of chum salmon in the Okhotsk Sea by a large scale salmon setnet fishery owned by the Ransu Fisheries Cooperative, Shiretoko Peninsula, Hokkaido.

Photograph taken by K. Soehata (Yamaha Motor Co. Ltd., 1980).



An encouraging haul of chum salmon by a small scale salmon setnet fishery owned by Shibetsu Fisheries Cooperative, Nemuro Strait between the Okhotsk Sea and Pacific Ocean, Hokkaido.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1980).

PHOTOGRAPH 2. Welcome back chum salmon! Prosperous catches have been derived from the success of the re-stocking programme in Japan.

A series of releases of reared fry with 3.5-4.5 cm fork length (FL) and 0.4-0.8 g body weight, is carried out during March to May every year. The actual timing of each release is dependent on the sea conditions (meteorology and nutrition) in the coastal areas at the time of release. The majority of released fry pass down the rivers to the sea within 10 days although some of the larger fry remain in the river for about one month. After descending, the fry inhabit inshore zones along the coast for about two months. They then start their offshore migration in the north and form large schools with the faster growing individuals schooling earlier. The minimum body size of the fish at the start of migration is estimated to be about 7 cm (FL) (Mayamama et al., 1982, Hashimoto, 1979). Age O-group fish however, remain mostly in coastal and offshore waters and gradually expand their habitat towards the open sea area (Neave, et al., 1976, Yonemori, 1975). At this stage, there is no overlap of habitat between the stocks which originate from Asia and those which originate from North America. However, juvenile fish of age-1 and older extend their habitat across the northern North Pacific reaching the Gulf of Alaska. At age 3 and older, the habitat is further extended to the east and north including the entire Bering Sea during spring to summer. The matured fish return to their natal rivers in northern Japan during autumn to early winter (Yonemori, 1975). During these later two stages the fish from both continents overlap in their migratory area.

It is noted that an intensive re-stocking project was launched in the USSR in 1981 in collaboration with Japan. In the Okhotsk Sea the chum salmon stocks are expected to recover in the near future.

7.1.3 Sockeye salmon, Oncorhynchus nerka (Walbaum)

The spawning rivers of sockeye salmon are widely distributed along the east and west coasts of the Kamchatka peninsula and the northern Okhotsk Sea coast. The majority of fish belong to the two stocks which originate from the Kamchatka River in eastern central Kamchatka and the Ozernai River in south western Kamchatka (Hanamura 1966). The fish live in fresh water for 2-4 years and in the ocean for another 2-4 years. The age at maturity is very variable and this results in a considerable variation in the age at which fish return to their natal rivers for spawning. The majority of returning fish however are composed of fish aged 4 to 6 years (Hanamura, 1966, 1967).

During their oceanic life, the fish gradually extend their migratory area towards the east year by year. However, this extension which reaches to about the eastern border of the area, 175-170°W, is less extensive than that of pink or chum salmon (Hartt, 1966, French et al., 1976). The overlap of distribution with fish of North American origin is therefore likely to be less than for pink or chum salmon.

The size of the sockeye population appears to be considerably less than that of pink or chum salmon (Table 6, Figure 4). Population size is believed to have declined during the late 1950's to 1960's but appears to be recovering in recent years (Figure 7, Appendix Table 1).

7.1.4 Coho salmon, Oncorhynchus kisutch (Walbaum)

The majority of coho salmon in the area originate from the rivers along the east and west coasts of Kamchatka. The spawning rivers are widely distributed along the northern Asian coast, and include the Anadyr River in the north, the Amur River in the south including Sakhalin and the northern part of Hokkaido (Godfrey et al., 1975). Most of the fish spend one (40-45 percent) or two (50-55 percent) years of life in the rivers while some (1-3 percent) spend three years. Oceanic life is limited to one year only for all these groups, and the fish then mature and return to their natal rivers. The age composition of the coastal catch therefore consists mostly of 2 and 3, partly 4 years old fish in the same ratios as referred to above.

The size of the coho population appears to be relatively small compared with that of pink, chum or even sockeye salmon. Catches have not varied widely and range from 6-11,000 t annually (Table 6, Figure 4). Of this 2-4,000 t come from the USSR coastal catch (Figure 7, Appendix Table 1).

7.1.5 Chinook salmon, Oncorhynchus tshawytscha (Walbaum)

The distribution of spawning rivers is quite similar to that for coho salmon (Major et al., 1978). The duration of both the fresh water and oceanic lives varies considerably, and ranges from 0-2 years for the fresh water period and 3-5 years for the oceanic period. The age at maturity is also variable ranging from 2-4 years for males and 4-6 years for females. This species is the largest of the salmons and a mature female frequently attains 100-120 cm body length with a range of 15-20 kg of body weight (Fukataki, 1968, Kato et al., 1982).

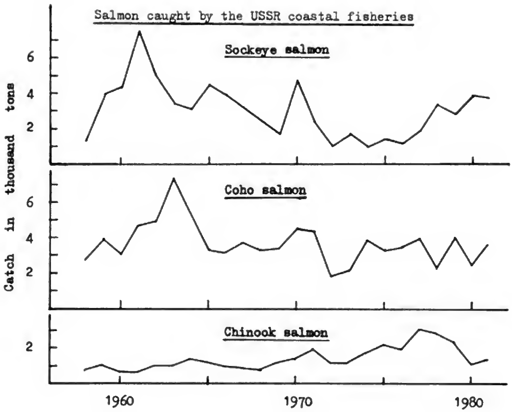


Figure 7. Catch of sockeye, coho and chinook salmon by the USSR coastal fisheries during 1985-81. See Appendix Table 1 for statistics.

Stock size is the smallest among the major salmons in the area and the fish are mostly taken as a by-catch when fishing for other salmons. Catches appear to have been relatively stable over the years with an annual catch of 3-4,000 t (Table 6, Figure 4) of this about 1-3,000 t comes from the USSR coastal catch (Figure 7, Appendix Table 1). This fishery has shown a clearly increasing trend since the early 1970's.

7.1.6 Cherry salmon, *Oncorhynchus masou* (Brevoort)

The distribution of cherry salmon is limited to the Asian side of the North Pacific (Kubo, 1980, Sugiwaka *et al.*, 1981, Machidori *et al.*, 1984). Major spawning rivers are located along the Okhotsk Sea coast, the east and west coasts of Sakhalin, the Primorskiy coast, and east and west coasts of northern Japan. The majority of the fish migrate to the sea after spending 1½ years in freshwater. They mature and return to their natal rivers after another 1½ years of oceanic life. During the oceanic period, the fish remain in the coastal to offshore areas in the Okhotsk Sea, the Japan Sea and the Northwestern Pacific, a characteristic which is different from those of the other oceanic salmons. They grow rapidly during their oceanic life and the size of spawners when they return to freshwater ranges from 50-70 cm.

Population size is very small, and probably the smallest among the salmons discussed in this paper. The Japanese catch has been fairly stable throughout recent years with an annual catch of about 3-4,000 t (Table 6) but the USSR catch is not known.

Biological features of the fish, especially for those originating from Japanese rivers, have been well documented by Machidori *et al.* (1984).

7.1.7 Summary for salmons

There are many encouraging signs relating to the salmon stocks in the area. First, many of the stocks which originate from USSR rivers and which had declined during the 1960's, have shown positive signs of recovery in recent years. This is so for pink (both odd and even year classes), chum, sockeye and chinook salmons (Figures 5, 7). The Japanese success in the re-stocking of chum salmon in Japanese rivers is most encouraging and has resulted in an increase in catch of about 80-90,000 t by the Japanese coastal fishery (Figure 6, Appendix Table 2). A similar re-stocking programme was recently initiated in USSR rivers with technical co-operation from Japan, and a substantial increase in the return of chum salmon to USSR rivers is therefore expected soon. Overall, it appears likely that even on a conservative basis the total salmon catch from the entire Northwest Pacific could increase by about 100,000 t. The total potential harvest could therefore be about 300-350,000 t.

The salmon is an important predator on pelagic fish, especially saury, herring and chub mackerel. Inter-specific relationships with these fish should therefore be more intensively studied in the future.

7.2 Demersal Fish

The number of demersal fish species that are commercially utilized is enormous, numbering up to one thousand. Out of these however, a relatively large part of the catch is accounted for by less than fifty species and these include stocks that were once intensively harvested and are now depleted. The total demersal fish catch from the entire area has been stable since around the mid-1970's at 6-5.5 million tons[1/]. In recent years the catch has shown a slight declining trend (Table 7, Figure 3).

Notable features of the demersal catches in the area are a sudden and remarkable increase in the catch of Alaska pollack, and a rapid and drastic decline of Pacific Ocean perch. In the long term, many species in the Yellow Sea and East China Sea have declined and there has been the discovery of demersal fish in the Central Pacific on the top of seamounts that are completely isolated from continental shelves or lands. The constant level of the total catch has therefore tended to mark many changes in the major resources and these will be discussed further in each of the following sub-sections.

1/ The total catch really taken is believed to be far beyond the level of nominal catch as will be discussed in the following sections in connection with the incompleteness of nominal statistics, see footnote in Table 7 for brief explanation.

Table 7

Catch of demersal fish[1/] by major species group during 1979-81.

('000 t)

Species	1970	1975	1976	1977	1978	1979	1980	1981
Alaska pollack	1,959	3,906	3,959	3,617	3,203	3,135	3,193	3,131
Pacific cod	74	96	60	71	65	67	68	93
Flatfish [2/]	258	312	303	267	325	259	265	266
Atka mackerel	166	220	296	291	179	158	127	123
Sandlances	227	275	224	137	103	111	201	164
Largehead hairtail	531	657	561	512	523	603	657	707
Other demersal fish[2/]	721	961	858	1,289	1,430	1,400	1,173	1,146
Total [2/]	3,936	6,427	6,261	6,184	5,828	5,733	5,684	5,630

1/ Catch by Korea D.P. Rep. is entirely excluded and the bulk of the Chinese catch is not included due to the incomplete species breakdown.

2/ In addition to the above, the total demersal fish catch is generally underestimated due to the incomplete species breakdown, especially for "Flatfish" and the "Other demersal fish". These may have been included under the heading of "Miscellaneous marine fishes" in the statistics reported from the other countries.

In this paper a few important major demersal fish species are assessed separately. Otherwise demersal fish are dealt with by species group, according to fishing zone, and on a regional basis.

Species or species groups dealt with separately are: Alaska pollack, Pacific cod, Atka mackerel, a grouping of four species of sandlance, a grouping of five species of rockfish. Then, there are: (1) flatfish in the Okhotsk Sea, (2) other demersal fish around Japan, (3) demersal fish in the Yellow Sea and East China Sea and (4) demersal fish on the seamounts in the Central Pacific. A summary and overall discussion is given at the end of this section.

7.2.1 Alaska pollack, *Theragra chalcogramma* (Pallas)

Alaska pollack are widely distributed in the northern North Pacific from the Asian coast to off North America through the Bering Sea without any marked interruption. Major concentrations however, are limited to several regions where intensive fishing has been carried out, i.e. the west and east coasts of the Japan Sea, around Hokkaido to southern Sakhalin, the east and west coasts of southern Kamchatka and the eastern Bering Sea. There is still uncertainty about stock identification. However, it is generally accepted that there are many local stocks continuously distributed along the coasts and that substantial mixing is likely to take place between neighbouring stocks (Kim, 1978, Kitano *et al.*, 1972, Maeda, 1972, Park, 1979, Takahashi *et al.*, 1972, Tsuji, 1972, Iwata, 1975). An analysis of the meristic characters suggests that there may be at least twelve major stocks in the entire northern North Pacific (Koyachi *et al.*, 1977). These comprise four stocks in the Japan Sea; i.e. at: (1) western Hokkaido, (2) northern Japan, (3) western Japan, and (4) Primorskiy-Korean Peninsula. Then there are two stocks, making up numbers 5 and 6, along the Kuril Islands-Hokkaido; i.e. (5) Kuril Islands, (6) east and southern Hokkaido. Then there are another two stocks in the Okhotsk Sea; i.e. there are numbers (7) at Sakhalin-Hokkaido, and (8) at northern Okhotsk. Then there are four more constituting numbers. Finally number (9) in the waters around the Kamchatka Peninsula, number (10) in the eastern Bering Sea, number (11) in the Gulf of Alaska and finally number (12) in the waters along the British Columbia coast. Another morphometric study and a study of the genetic characteristics of protein enzymes suggests that the stocks around northern Japan and in the Okhotsk Sea should be further subdivided into several local groups (Iwata, 1975). Details of the structure of each stock or local group and the degree of mixing between them have not been worked out. For the time being however the above assumptions can be useful for practical purposes. Two of

the stocks referred to above fall completely outside of the area dealt with in this paper while the western part of the eastern Bering Sea stock is within the area.

The biomass of all the stocks of Alaska pollack is the largest out of all the demersal resources in the area and the total annual catch of this one species since the early 1970's has ranged from about 2-4 million tons. This exceeds the catch of any other species, including pelagic fish, until 1981 when the catch of Japanese sardine exceeded that of Alasak pollack (Table 7, Figure 8, Table 9).

The Japanese catch increased rapidly during the 1960's and reached about 2 million tons in the early 1970's. The industry was stimulated by a strong domestic demand and by the development of a new technology for processing referred to as "minced-meat" which was done both on board and onshore. The catch declined sharply after the mid-1970's and the recent annual catch has been stable at about 1 million tons (Figure 8, Appendix Table 3). The Japanese catch from the Northwest Pacific comes from the Okhotsk Sea (40-50 percent), the northern Bering Sea (15-20 percent) and the Pacific coast of northern Japan (25-30 percent). The catch from the Japan Sea has been relatively small, and makes up less than 10 percent of the total. The sharp decline in the Japanese catch during the mid 1970's was due initially to regulations established through bilateral negotiations with the USSR and the U.S.A. and more recently to regulations imposed in connection with the extended national jurisdiction by these two countries. Since 1977, catch quotas have been imposed on the Japanese fishery in USSR waters (0.35-0.29 million tons) and U.S.A. waters (0.70-0.77 million tons including the eastern Bering Sea).

The USSR catch also increased rapidly during the period 1965-75 and the catch, which is believed to come mainly from the Kamchatka and northern Okhotsk stocks, is still increasing. In recent years the catch exceeded 2 million tons (Figure 8, Appendix Table 3). The USSR fishery has also been catching pollack in Japanese waters along the Pacific coast of northern Japan for which a catch quota has been imposed annually (80-10,000 t) since 1977. No information is available for the USSR catch in the Japan Sea.

The Korea Republic had traditionally depended on the Primorskiy-Korea stock of pollack and on catches taken from coastal waters. Catches were relatively small with an annual catch of about 20-30,000 t but since 1971 catches increased due to the exploitation of the Kamchatka stock (Lim et al., 1978). There was a relatively rapid increase in catch followed by a relatively rapid decline. The decline was due to a reduction of the fishing in the region due to the extension of national jurisdiction by the USSR (Figure 8, Appendix Table 3).

It is believed that Korea, D.P. Rep. has also been catching pollack in the Japan Sea, but no details are available. If it is assumed that about 50 percent of the estimated total fish catch is demersal fish, and that pollack accounts for about 30 percent of the demersal fish catch, then about 200-300,000 t of Alaska pollack must be taken annually by this fishery.

The eastern Bering Sea stock appears to have remained stable at a favourable level in recent years. The catch quota has been set at a high level of about 1 million tons, and about 10-20 percent of this, 100-200,000 t annually, is estimated to have been taken from the Northwest Pacific (central Bering Sea, west of 175°W). Assessments of this stock have been made at annual meetings of the INPFC scientific sub-committee but details of the results are not known.

The two stocks in and around the southern Okhotsk Sea (the Sakhalin-Hokkaido and Kuril Island stocks), on which intensive fishing has been carried out by the Japanese fishery in recent years, appear to be stable. The majority of the Japanese catch has been taken from the USSR fishing zone and the catch quota imposed on the fishery during 1980-83 has been kept at the same level - i.e. at 290,000 t annually. This accounts for about one third of the total pollack catch by the Japanese fishery from the entire area. Assessments of these stocks have been made at the annual meetings of the Japanese-USSR Fisheries Convention every year, but details of the results are not known.

The status of the northern Okhotsk stock and of the Kamchatka stocks, which is probably the largest in the area, are not known. Exploitation of these stocks has been almost exclusively carried out by the USSR fishery since 1977. It is noteworthy that the total USSR catch is still growing although in recent years the rate of increase appears to have slowed down (Figure 8, Appendix Table 3). These stocks have been probably fully exploited.

The stocks along the Pacific and Japan Sea coasts of Japan also appear to have been stable throughout the years judging from the lack of trend in the Japanese coastal catches. These do however exhibit annual fluctuations.

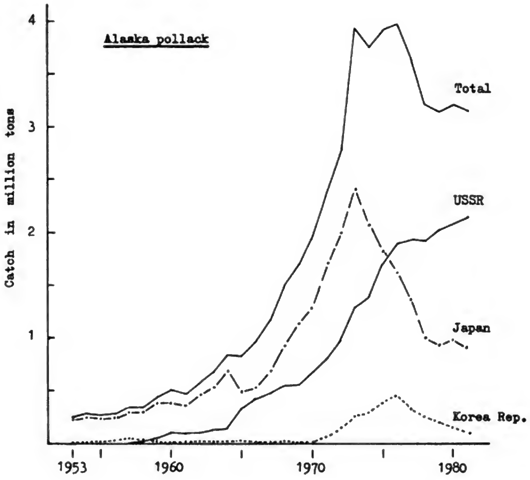


Figure 8. Catch of Alaska pollack by country during 1953-81. See Appendix Table 3 for statistics.

Nothing is known about the Primorskiy-Korea stock due to the complete lack of information from the USSR and the Korea, D.P. Rep. fisheries. It is believed however that these countries exploit the stock intensively.

Overall, Alaska pollack appears to have been stable at a high level in the area generally. However, exploitation may have nearly reached its maximum level. Further substantial increases in the total catch are therefore unlikely to be achieved in the future and the total potential for the area is probably about 3-3.5 million tons.

It is interesting to note that the surveys carried out by the Japanese research vessels has confirmed that a substantial number of pelagic living Alaska pollack inhabit the surface and midwater layers of the 3-4,000 m deep Aleutian Basin, much of this falls in the area (INPFC, 1980, 1980a, 1984). These schools are comprised completely of large adult fish ranging from 40-60 cm fork length. These fish are considered to be associated with stocks in the area and not to be an isolated population. Should this component of the stock contribute substantially to the total, the potential yield of pollack could be higher than that estimated above.

7.2.2 Pacific cod, Gadus macrocephalus Tilesius

Like Alaska pollack Pacific cod is also widely distributed in the northern part of the Northwest Pacific but its biomass is considerably smaller, and the tendency to shoal is very much weaker than that of Alaska pollack. Pacific cod appear to be distributed in many local stocks, but not much is known about these, or about the biological characteristics of the species.

Due to the scattered distribution of Pacific cod, the majority of the catch is taken incidentally by several fisheries which are directed at other target species such as pollack and flatfishes. The total catch by the three nations concerned, (Japan, USSR and Korea Rep.) has been rather stable during the past two decades with an annual catch of 70-100,000 t (Table 7, Figure 9, Appendix Table 4). The Japanese catch which had traditionally accounted for the largest component of the total, has decreased substantially since the mid 1970's while the USSR catch has shown a rapid increase in recent years (Figure 9, Appendix Table 4). As in the case of Alaska pollack this is due to a reduction in fishing by Japan and the Korea Rep. and an intensification of fishing by the USSR in the USSR fishing zone. The Japanese catch from coastal waters around northern Japan, however, has been fairly constant for the past two decades with an annual catch of 30-40,000 t. The catch by the Korea Rep., which has depended mostly on the coastal resources, has also been constant throughout the years though the size of this fishery is extremely small (Figure 9, Appendix Table 4).

The stock abundance in the entire region is considered to be fairly constant though most stocks appear to be fully exploited.

7.2.3 Atka mackerel, Pleurogrammus spp.

Atka mackerel occurring in the Northwest Pacific comprises two species, Pleurogrammus monopterygius (Pallas) and P. azonus Jordan et Metz. The former species is distributed widely in the northern North Pacific from the Asian coast (north of Hokkaido) to the north American coast. The latter species is found further south and is limited to the Asian coast (Kuril-Sakhalin to northern Japan). The total catch has been quite large, in spite of the fact that the commercial value is relatively low and the market is rather limited and equivalent to about half of the total flatfish catch from the entire area (Table 7, Figure 10).

Details of the composition of the stocks and the biological features of the fish are not well known except in the case of P. azonus around the northern part of Japan. P. azonus along the Japanese coast seems to be composed of many small local stocks (Japan, Fisheries Agency, 1973, 1976, Kitakata et al., 1967, Kitakata, 1968). There are many local groups found along the entire coast of Hokkaido which show a strong tendency to shoal but which segregate sporadically during the spawning season (October-December). During the feeding season there is an overlap of neighbouring groups. Considerable mixing of groups may also take place while the larvae and fry are widely distributed in the offshore waters when these are pelagic. The habitat changes from surface to bottom and vice versa, according to the growth stage. As a consequence, fish are caught by pelagic and demersal gears in Japan; i.e. by trawl at the early 1 year old stage by purse-seine from 1½ years old and by bottom gill-net and longline after 2-3 years old when they mature and become sedentary spawners.

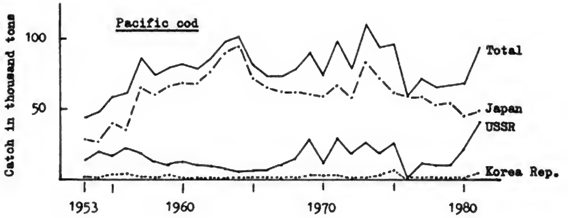


Figure 9. Catch of Pacific cod by country during 1953-81. See Appendix Table 4 for statistics.

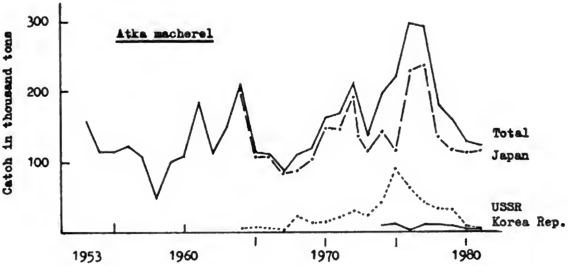


Figure 10. Catch of Atka mackerel by country during 1953-81. See Appendix Table 5 for statistics.

The Japanese catch, which is composed almost entirely of P. azonus, has been prominent throughout the years (Figure 10, Appendix Table 5) fluctuating from 100,000 to 200,000 t annually. There has been no consistent trend during the past decade. It is said that a large fluctuation in catch can result from changes in market demand and in the availability of other commerially valuable fish (Japan, Fisheries Agency, 1976). When this is taken into account, it seems likely that the abundance of the stocks has remained fairly stable and it is thought that the stocks may not yet have been fully exploited.

The species composition of the catch taken by the USSR and Korea Rep. fisheries is not known. The former probably includes P. monopterygius in the Okhotsk Sea and the latter may consist mostly of P. azonus. The USSR fishery increased during the mid 1970's, but the catches by the USSR and the Korea Rep. have traditionally been very small (Figure 10, Appendix Table 5). Not much is known about the fishery along the west coast of the Japan Sea, including that due to the Korea D.P. Rep.

7.2.4 Sandlances, Ammodytidae

Four species of sandlances have been reported by many scientists from the area, i.e. (1) Pacific sandlance, Ammodytes personatus Girard, (2) northern sandlance, A. hexapterus Pallas, (3) Taiwan sandlance, Embolichthys mitsukurii (Jordan et Evermann) and (4) Korean sandeel, Hypoptychus dybowskii Steindachner. However, the taxonomic status of these four species has not yet been completely confirmed. For instance, a few scientists think the first two are sub-species with locally varied morphometric characters and many scientists classify the last two in different families or even in different order.

It has been generally accepted by the majority of scientists, that Pacific sandlance, A. personatus is the most important of the four species. This species is widely distributed in both the cold and warm waters around Japan (Inoue, 1967, Japan, Fisheries Agency, 1976, 1976a, Kitaguchi, 1979) while the northern sandlance, A. hexapterus is distributed further north and only in cold water (Inoue, 1967, Kitaguchi, 1979). The Korean sandeel, H. dubowskii is reported only from the cold water along the coasts of north-central Japan and Primorskiy-Korea, while the Taiwan sandlance, E. mitsukurii is found in warm water further south from central Japan to Taiwan, Province of China.

The nominal catch of Pacific sandlance, taken in the Japanese fishery has made up a significant part of the demersal fish from the Northwest Pacific (Table 7, Figure 11, Appendix Table 6) in spite of its relatively low commercial value. These catches probably include some northern sandlance. The status of the fishery resembles that of Atka mackerel, and the increased level of fishing since the late 1960's has resulted mostly from the strong domestic demand for feed for aquaculture and especially for yellowtail farming. These fish are taken mainly by trawl, liftnet and surrounding net.

Figure 11. Catch of sandlances by country during 1953-81. Four species are probably involved but the taxonomic status of those has not yet been confirmed, see text. See Appendix Table 6 for statistics.

Pacific sandlance are eurythermous and strongly prefer a sandy bottom where there are rapid tidal currents. The fish is distributed widely along the Japanese coast where conditions are favourable regardless of the water temperature. It is interesting to see the fact that these fish aestivate in the sand when the water temperature rises in summer in the southern waters around Japan which may be consistent with the eurythermal nature of the fish (Inoue, 1967). The rates of growth and maturation vary according to environmental conditions including variations in the quality and quantity of zooplankton available for food. The fish generally mature at age-1 and die off after age-2.

At least six major stocks of Pacific sandlance are distinguished around Japan. These are the Sakhalin-Hokkaido, Hokkaido Pacific, Hokkaido Japan Sea, Honshu Pacific, Seto Inland Sea and the Honshu Japan Sea (Inoue, 1967, Kitaguchi 1979, Japan, Fisheries Agency, 1976, 1976a). These are supposedly further subdivided into smaller local groups. An important characteristic of this fish is that it is an important food resource for other comercially important demersal fish species, and large numbers are commonly found in the stomachs of predatory fish species. From the available information, the abundance of Pacific sandlance around Japan seems to be at a very high level. The rate of exploitation may not yet have surpassed the maximum level though it may be close to this point.

The nominal catch by the Korea Rep. fishery is reported to be exclusively that of Korean sandeel, H. dybowskii. However, there is some doubt about the species identification, and the Korean catch is possibly a mixture of Korean sandeel and Pacific sandlance. The catch has been very small throughout the years (Figure 11, Appendix Table 6). There is little information on the abundance, biological features and magnitude of exploitation of these stocks.

It is quite likely that the USSR and Korea D.P. Rep. fisheries exploit sandlance in the Okhotsk Sea and in the western Japan Sea, but no information is available.

7.2.5 Rockfishes, Scorpaenidae

There are about forty species included in this category that are reported to have been commercially utilized from the waters around Japan. However, most of them have a very small biomass and a scattered distribution. They are taken mostly as incidental catches by various gears and directed fishing occurs for only a few species.

The fish are boreal in nature and most species are distributed in cold water along the coasts of northern Japan, the Kuril Islands, the Aleutian Islands and Primorskiy-Korea. Some species inhabit warm waters. The major species in the northern group, which are caught in significant quantities by directed fishing, are: (1) Pacific ocean perch, Sebastes alutus (Gilbert), (2) "Baramenuke", S. baramenuke (Wakiya), (3) "Sankomenuke", S. flammeus (Jordan et Starks), (4) "Oosaga", S. iracundus (Jordan et Starks) and (5) spinycheek rockfish Sebastolobus macrochir (Günther). For these species a further detailed review will be given later. They are taken mostly by trawl and bottom longline.

Commercially important warm water species, which are distributed along the south and west coasts of Japan to the East China Sea, are: (1) "Mebaru", Sebastes inermis Cuvier et Valenciennes, (2) "Akoodai", S. matsubarai Hilgendorf, (3) "Kurosoi", S. schlegeli Hilgendorf, (4) "Takenoko Mebaru", S. oblongus Gunther and (5) "Murasoi", S. pachycephalus pachycephalus Temminck et Schlegel. It is difficult to make a detailed review due to the lack of information. They are taken by various gears including handlines, trawl, bottom gillnet and longline.

The Pacific ocean perch, Sebastes alutus is widely distributed in the northern North Pacific from the Kuril Islands to the northern American coast through the Aleutian chain and the Bering Sea (Chikuni, 1975). The fish inhabit the outer part of the continental shelf and the upper part of the continental slope, where it is 100-400 m deep, though the habitat of fish younger than 4-5 years old is not well known. The growth is extremely slow and the lifespan is very long. For example, 32 cm body length at age 10, 38 cm at age 15, 41 cm at age 20. The oldest age recorded is 23. The age at first maturity is also relatively old, at age 7-8. The fish is an ovoviviparous and the fecundity is relatively small, numbering about 30,000 eggs at age 10 and 75,000 eggs at age 15. These biological characteristics suggest that stocks may be vulnerable to heavy exploitation and that recovery may be slow if the stock has declined.

Four major stocks have been identified in the northern North Pacific. These are: (1) Kuril Islands to northern Bering Sea, (2) Aleutian Islands, (3) Gulf of Alaska and (4) Eastern Pacific stocks. Each of these stocks seem to be further subdivided into many small local groups. The western part of the first two stocks is included in the Northwest Pacific while the last two fall entirely outside.

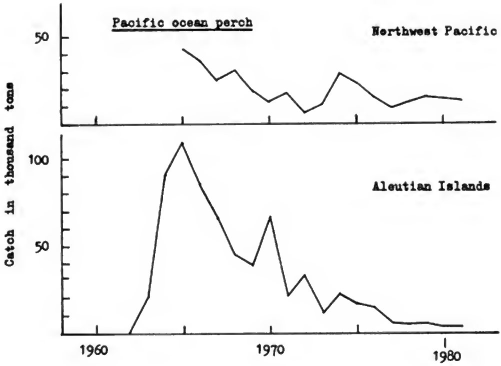


Figure 12. Catch of Pacific ocean perch from the Northwest Pacific and from the waters along the Aleutian Islands. See Appendix Table 7 for statistics and an explanatory note for these areas.

Intensive fishing was initiated in 1960 by the USSR and Japanese fisheries. Fishing started in the waters along the continental slope in the eastern Bering Sea, and then expanded to the Aleutian chain where the majority of the catch from the entire Bering Sea had been taken during the 1960's. The total catch from the area declined drastically during the later half of the 1960's, only 5-10 years after the initiation of fishing, and was a consequence of a decline in stock abundance along the Aleutian Islands (Figure 12, Appendix Table 7). The age composition of the catch changed drastically during this period, characterised by a rapid decline in the proportion of older fish. The level of recruitment also showed a marked decrease during the later half of the 1960's. This is consistent with the results of overexploitation (Chikuni, 1975).

Fishing on these two stocks (Kuril Islands-Bering Sea and Aleutian Islands stocks) has been severely restricted since 1977 in connection with the extension of jurisdictional waters by the U.S.A. and the USSR. The Japanese catch from the Bering Sea and the Aleutian region has been limited annually to about 4,000 t in recent years while the USSR fleet seems to have virtually withdrawn from the region. Nevertheless, there has been no definite indication so far of a recovery of these resources.

The recent Japanese catch of Pacific ocean perch seems to have been taken mostly from the USSR fishing zone along the Kuril Islands where a catch quota of about 18,000 t, including other rockfishes, has been set.

"Baramenuke", Sebastes baramenuke, "Sankomenuke", S. flameus and "Oosaga", S. iracundus are commercially important rockfishes along the northern Pacific coast of Japan. Not much is known about the biological features of these species, but like Pacific ocean perch, they may be vulnerable to exploitation. Their abundance is comparatively small with a combined annual catch of about 10,000 t. Intensive fishing on these resources had been carried out during the 1950-60's and both the catch rate and the total catch declined within only a few years of the commencement of fishing (Japan, Fisheries Agency, 1973). Since then the combined total catch has remained constant. The stock abundance is considered to be at equilibrium at a very low level.

Spinycheek rockfish, Sebastolobus macrochir is also a commercially important species and is widely distributed along the northern coast in the area. However, the main catches come from the Pacific coast of northern Japan. The fish seem to be rather stationary in nature with many local stocks but many of the biological features are still unknown, and probably similar to that of other northern rockfishes. The catch from the Pacific coast of Hokkaido and northern Honshu, which decreased during the late 1950's, has been fairly constant with an annual catch of about 10-13,000 t during the past two decades. The stocks are considered, like those of other rockfishes, to be at equilibrium at a very low level.

7.2.6 Flatfish in the Okhotsk Sea

The total catch of flatfish from the Okhotsk Sea has been considerable, probably accounting for 10-15 percent of the total flatfish catch from the entire Northwest Pacific. Commercially important species however are few in number i.e. (1) yellowfin sole, Limanda aspera (Pallas), (2) rock sole Lepidopsetta spp. and (3) flathead sole, Hippoglossoides spp. Yellowfin sole is the most important and has been intensively exploited by directed fishing. The others are rather scattered and are caught mostly as by-catches in the fishery for yellowfin sole and Alaska pollack.

Yellowfin sole, Limanda aspera, is widely distributed on the continental shelf in the sea extending to the Hokkaido-Kuril Islands in the south and Promorskiy-Korea in the Japan Sea in the west. However, the most important concentration is located along the west coast of Kamchatka where intensive fishing has been carried out by the USSR and Japan (Japan, Fisheries Agency, 1976). The USSR catch during the later half of the 1950's was quite large, ranging from 70-100,000 t annually (Figure 13, Appendix Table 8). After this the catch per-unit-effort showed a sharp decline for a few years successively (Japan, Fisheries Agency, 1976). The abundance of the stock is therefore considered to have declined during these periods and the catch has remained constant at a low level. The Japanese fishery had also taken a substantial amount of yellowfin sole from the west Kamchatka region during the period 1960-1975 (Figure 13, Appendix Table 8). The fishery included fishing with motherships during the period since 1965 when a fairly constant catch per unit effort was observed (Japan, Fisheries Agency, 1976). Fishing in the region ceased however after 1977 due to the establishment of the exclusive fishing zone by the USSR. The Japanese catch in recent years has depended thereafter mostly on the Sakhalin-Hokkaido and Kuril Islands regions. For these regions a catch quota has been set by the Japan-USSR Fishery Convention.

The state of exploitation in recent years for other species is not clear due to the lack of information. The catch per-unit-effort of the Japanese fishery in the west Kamchatka region during 1965-75, when there was a considerable fishery, has shown little evidence of trend (Japan, Fisheries Agency, 1976). The stocks are considered therefore to have probably been at equilibrium at a low level as in the case of yellowfin sole.

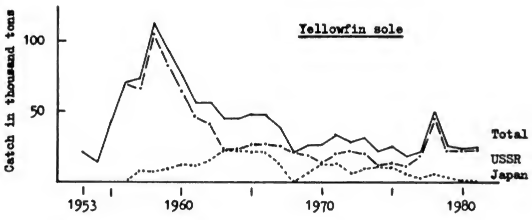


Figure 13. Catch of yellowfin sole by country from the Okhotsk Sea. The catch by the USSR fishery includes other flatfishes, making up 20-40 percent of the total, see text for details. See Appendix Table 8 for statistics.

7.2.7 Other demersal fish around Japan

Other demersal fish from the coastal waters around Japan have been intensively exploited for many years. The estimated total catch is quite large with about 300,000 t annually and this accounts for about 5-8 percent of the total demersal fish catch by all nations from the entire area or 3-8 percent of the total fish catch by the Japanese fishery in the area. This species group is composed of a large number of species without any single species predominating. In Japan the fish commonly taken and commercially sold at wholesale markets exceeds 250 species. They are caught by various gears in mixed fisheries, or as incidental catches in fisheries directed at other species.

The major component of the catch, which is estimated to account for about 70-80 percent of the total (Figure 14, Appendix Table 9), are: (1) various species of flatfishes, Pleuronectiformes, (2) sea breams, Sparidae, (3) Japanese sandfish, Arctoscopus japonicus (Steindachner), (4) lizard fishes, Synodontidae, (6) croakers, Sciaenidae, (7) daggertooth pike-conger, Muraenesox cinereus (Forsskål) and (8) Japanese butterfish, Psenopsis anomala (Temminck et Schlegel). Japanese sandfish and several flatfish species are boreal and distributed along the Pacific and Japan Sea coasts of northern Japan. The remainder are temperate species inhabiting warm waters along the south and west coasts.

The biological characteristics of some of these species have been studied in detail but detailed assessments have not been carried out owing to the complexity of the fish communities and of the fisheries. These species are generally caught in mixed fisheries by various fishing gears and each gear is operated by several fishing power categories with different fishing efficiencies. Because of this it is difficult to assess the stocks, to develop a management strategy, or to implement management measures for any one stock. In this respect, these resources resemble tropical demersal fish stocks. Management of the coastal fishery in Japan has therefore been based on the limitation of total fishing power in regionally defined fishing grounds by means of a licensing system (Asada, 1973, Asada et al., 1983). This appears to have worked out well on the whole, and may have been responsible for the maintenance of fairly constant catches for the major species/groups throughout the years (Figure 14, Appendix Table 9). It is generally believed that most of the species/groups are now fully exploited and are at equilibrium at a low level (Japan, Fisheries Agency, 1973, 1976, 1976a).

7.2.8 Demersal fish in the Yellow Sea and East China Sea

The Yellow Sea and East China Sea are characterized by the extent of continental shelf from the coast of China and the Korean Peninsula as was discussed in Section 1 in this paper (Table 1, Figure 1). The demersal fish resources in the region are correspondingly large, due to the large area of shelf and the favourable oceanographic conditions as was discussed in Sections 2, 3, 4 and 5.

Another feature of the region is that these resources have been utilized by several nations for many years, i.e. by China, Korea Rep., Korea D.P. Rep., Hong Kong and Macau as coastal countries and by Japan, which joined the fishery in the late 1900's as a non-coastal country. However, as a result of the heavy fishing, especially after World War II, most of the major resources have become depleted. Nevertheless in spite of incomplete catch data, the recorded catch from the region in recent years still exceeded 1 million tons (Table 8). It is estimated on a conservative basis that at least 1.5 million tons of demersal fish may have been taken from the region (Table 5-(3)).

The nominal total catch reported from China has been far above that of the Korea Rep. and Japan (Figure 15, Table 8). It is further believed that the Chinese catch is really much greater than the nominal catch as the reported catch comprises only three major species, large yellow croaker, small yellow croaker and largehead hairtail (Appendix Table 10-(1)). Due to this incomplete reporting the true total catch is unknown.

The estimated Korean and Japanese catches, are both believed to be reliable, and both have remained fairly constant in recent years. However, in the longer term, the Korean catch has been steadily increasing whereas the Japanese catch has been decreasing (Figure 15, Table 8). The decline in the Japanese catch has resulted from various causes. These are: (1) a decrease in catch rate, especially of commercially valuable fish has been due mostly to a decline in stock abundance, and has reduced the overall catch, (2) the higher cost for fuel and labour has reduced the profitability of the fishery and caused a decline in the total number of fishing enterprises and (3) enforcement of the regulations imposed on the Japanese fishery by the China-Japan Fisheries Agreement has directly suppressed fishing (Figure 16, Appendix Table 10-(2)). The decline in the species catch is most marked in commercially important species such as yellow croaker, black croaker, daggertooth pike-conger, red sea bream and yellow sea bream. The implied reduction in stock size is extremely serious

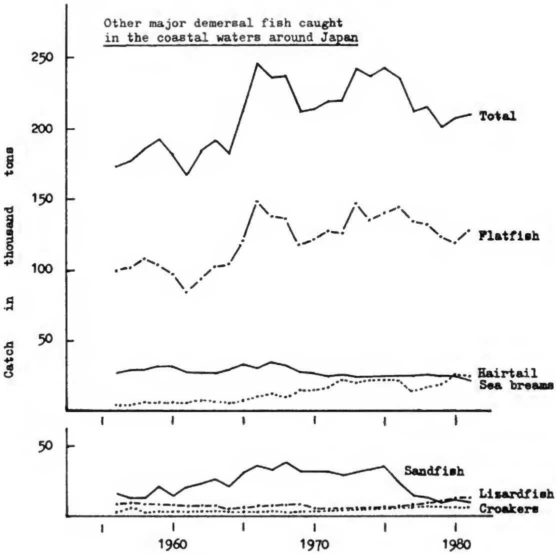


Figure 14. Catch of other major demersal fishes from coastal waters around Japan during 1956-81. See Appendix Table 9 for statistics and text for the species involved.

PHOTOGRAPH 3. A red sea bream caught by traditional handlining by a skilful fisherman of the Mogi Fisheries Cooperative, Tachibana Bay, western Kyushu, Nagasaki prefecture. The fish are kept alive in a hold (on board) and in a cage (nearshore stocking) until they are sold at the wholesale market under control of the Cooperative.

Photograph taken by Y. Hondo (Yamaha Motor Co. Ltd., 1979).

Table 8

Catch of demersal fish by country[1/] in the Yellow Sea and East China Sea during 1956-81. See Appendix Table 10 for details of the statistics.

('000 t)

Year	Japan[2/]	Korea Rep.[3/]	China[4/]	Total[5/]
1956	324			
1957	337			
1958	352			
1959	357			
1960	368	?		
1961	375			
1962	331			
1963	345		?	?
1964	302			
1965	325	117		
1966	334	135		
1967	338	150		
1968	326	122		
1969	304	137		
1970	279	178	581	1,038
1971	257	171	607	1,035
1972	219	216	665	1,100
1973	221	247	734	1,202
1974	219	341	775	1,335
1975	210	257	624	1,091
1976	185	229	557	971
1977	206	185	484	875
1978	198	192	481	871
1979	199	240	556	995
1980	199	262	596	1,057
1981	184	293	614	1,091

1/ No data is available for the catch by Korea D.P. Rep. In addition to this the catches by the three countries appear to have been substantially underestimated due to the reasons mentioned below.

2/ Only offshore trawl fisheries are involved. Catches by other gears and by the coastal trawl fishery in shallower waters along the Japanese coast, are not included.

3/ Includes the catch of demersal fish by all fishing gears but excludes the catch of miscellaneous demersal fish which were not specified in the national statistics.

4/ The catch comprises only three major species, large and small yellow croakers, and largehead hairtail. Filefish and fleshy prawn will be dealt with separately in later sections.

5/ Only the summation of the given figures. The total demersal fish catch from the region is considerably greater than these figures for the reasons mentioned above, especially in 3/ and 4/. The catch by Taiwan, Province of China (300,000-400,000 t) is not included due to the large difference in species breakdown making it difficult to incorporate this into the catch-by-species nominally reported by the above nations.

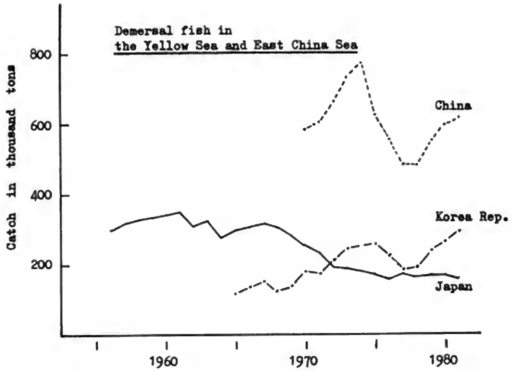


Figure 15. Total catch of demersal fish by country from the Yellow Sea and East China Sea. The catches by China and Korea Rep. do not include all species. See text, Table 8 and Appendix Table 10 (1: China, 2: Japan and 3: Korea Rep.) for details and problems involved in statistics. Catch by Korea D.P. Rep. is not known.

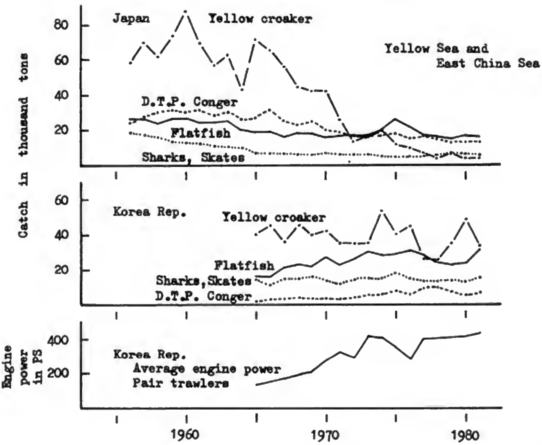


Figure 16. Comparison of the catches of the major demersal fish species in the Yellow Sea and the East China Sea by Japan and Korea Rep. An indication of the change in fishing power of Korean pair trawlers is also shown. See Appendix Table 10 (2: Japan and 3: Korea Rep.) for statistics.

when the remarkable improvement of fishing efficiency in the Japanese fishery during the period is taken into account, (i.e. an increase of about 1.4 times during the period 1955-70) (Kitajima et al., 1973).

In contrast, the continuous increase in the Korean catch has undoubtedly resulted from a remarkable increase in fishing efficiency. It is reported that the fishing efficiency of the trawl fishing in the region has increased by 1.1-1.3 times during the period 1972-79 (Hwang et al., 1982). For example, during this period, the engine power of trawlers has increased 2.7 times and the catch per unit engine power has shown a substantial decline for many species over the period ((Figure 16, Appendix Table 10(3)). It should be noted that stow-nets[1/] catch almost as large a quantity of demersal fish as the trawl fishery (Hwang, 1977). Although historical data on the stow-net fishery are not available, there may be no doubt that the improvement in the fishing efficiency of this fishery has also contributed to the increase in catches, and this may have also been associated with an increase in the number of grounds fished.

The number of species commercially harvested is about 100 including cephalopod and crustacea (Nakashima et al., 1972). The major fish species, which are taken in quantity or are of high commercial value include lizardfish, Saurida spp., daggertooth pike-conger, Muraenesox cinereus (Forsskål), largehead hairtail, Trichiurus lepturus Linnaeus, Japanese butterfish, Psenopsis anomala (Temminck et Schlegel), large yellow croaker, Pseudosciaena crocea (Richardson), yellow croaker, Pseudosciaena polyactis Bleeker, white croaker, Argyrosomus argentatus (Houttuyn), black croaker, Atrobucca nibe (Jordan et Thompson), red sea bream, Pagrus major (Temminck et Schlegel), golden threadfin bream, Nemipterus virgatus (Houttuyn), yellow sea bream, Dentex tumifrons (Temminck et Schlegel), flathead, Platyucephalidea, sea robin, Triglidae, bastard halibut, Paralichthys olivaceus (Temminck et Schlegel), flatfish, Pleuronectidae, tongue fish, Cynoglossidae and filefish, Navodon modestus (Günther).

Most of these fish are distributed in several local stocks and their spawning grounds are located in shallower waters along the Chinese coast (Seikai Reg.Fish.Res.Lab., 1955, Shindo, 1963). They migrate to offshore waters in accordance with their growth. The fish are harvested therefore by both the coastal fisheries (China, Korea Rep., Hong Kong and Korea D.P. Rep.) and also the offshore fisheries (China, Korea Rep. and Japan). Information on the coastal fisheries is very sparse and the biological features of the young stages and the fishing intensity on them are not known. However, the biological characteristics of the offshore stages and the fishing on these have been intensively studied by Japanese scientists. The major reports published are: Shindo (1960) for yellow sea bream, Misu (1964) for largehead hairtail, Ōtaki (1964) for daggertooth pike-conger, Ikeda (1964) for yellow croaker, Sato (1974) for black croaker, Okada (1974) for red sea bream, Saishu (1970, 1973, 1974a) and Saishu et al., (1970) for the reproduction of yellow croaker, yellow sea bream, red sea bream and lizard fish, Kibezaki (1960) and Nakashima et al., (1972) for a comprehensive analysis of catch-and-effort data, Aoyama (1961) for the selectivity of trawl net, Kitajima (1972) and Kitajima et al., (1973) for the fishing efficiency of trawl vessels.

The results of these studies show clearly that most stocks were depleted during the period 1955-1970, although these are exceptions for white croaker, largehead hairtail and filefish which will be discussed later on. The decline in stock abundance took place for a number of species consecutively and the stocks have not recovered since they were depleted. The Japanese offshore fishery has had to change target species in response to declines in the abundance of the various stocks (Mio, 1977). The number of spawners in each stock has decreased drastically during the 1960's (Saishu, 1974) and seriously affected the reproductive potential of those stocks (Saishu, 1970, 1973, 1974a, Saishu et al., 1970). This is particularly so for red sea bream, yellow sea bream, black croaker and yellow croaker. For example, even in the early 1970's the offshore abundance of red sea bream was estimated to be only $^1/5$th - $^1/7$th of its previous level (Okada et al., 1972). The abundance of spawners of black croaker decreased rapidly to about $^1/10$th during the 1960's (Saishu, 1974) and yellow sea bream to about $^1/8$th during the same period (Saishu, 1973). The offshore abundance of yellow croaker also declined down to about $^1/5$th and this was accompanied by a substantial reduction in the distribution, (Ōtaki et al., 1978), and an increase in growth rate and earlier maturation (Mio et al., 1975).

A sharp decline in the abundance of yellow croaker was reported also from Korean waters and associated with a decrease in the proportion of older fish in the catch (Hwang, 1977a, Kim, 1977). It is noted that immature fish, less than two years in age, now account for more than 80 percent of the total Korean catch (Lee, 1977). An overall decline in catch-per-unit effort has also been reported

1/ Streamer-type set net, see footnote in Section 6.2.6.

from Taiwanese and Hong Kong trawl fisheries which have been operating extensively along the Chinese coast including the northern part of the South China Sea (Liu et al., 1979, Richards, 1982). It appears therefore that a decline in stock abundance is the general pattern for most of the stocks in the entire region including the northern part of the South China Sea along the Chinese coast and that this decline was due to heavy fishing both by the coastal and offshore fisheries. However, information on the coastal fishery is almost unavailable. The numbers of fishermen and fishing boats are enormous along the Chinese coasts (Zhu, 1980). The fishing effort in coastal waters where many stocks spawn, and where there are nursery areas must therefore be quite intensive. Studies of these coastal fisheries are urgently required therefore to establish a firm basis for the rational exploitation of the stocks. It should be specifically noted here that the stow-net may have played an important role in causing the mortality of many juvenile demersal fish. This gear, which is commonly used in Korea Rep., China and probably in Korea D.P. Rep., is non-selective for smaller fish even including fry. The high catch compositon of 0-1 age yellow croaker in Korean waters for example, (Lee, 1977) clearly shows the nature of the gear. Reasonable assessments of these stocks will not be possible therefore until these features can be fully taken into account.

White croaker is the only species which does not show a substantial decline in abundance even though this species has been exposed to as much fishing as other species (Shojima et al., 1983). Although stock abundance and the proportion of older fish decreased substantially during the initial stages of exploitation and the level of fishing now exceeds the theoretical optimum, the stock appears to be fairly stable. The reason for this is not clear.

Two stocks that have been heavily fished in recent years are largehead hairtail and filefish. The Chinese catch of largehead hairtail has been prominent followed in importance by the Korean catch (Figure 17, Appendix Table 10-(3)).

Although the Japanese catch has declined since 1970, this may have resulted mostly from a decline in the fishery as was described earlier (Figure 17, Table 10-(2)). The fish seem to be composed of several local stocks (Misu, 1964, Luo et al., 1981). Detailed assessments of the stocks have not been made as yet, but it is thought that the stocks may be fully exploited or even slightly overexploited (Gu, 1980).

The filefish, Navodon modestus is an unusual species which increased suddenly in abundance in the Northwest Pacific during 1965-75. This increase was observed firstly in the waters around southern and western Japan in the late 1960's and was then seen further south in the waters along the Korean coast and the East China Sea a few years later (Figure 18, Appendix Table 10-(4)). Although the nominal catch of the Korea Rep. has been attributed to the threadsail filefish or Stephanolepis cirrhifer (Temminck et Schlegel), there is no doubt that the majority of the reported catch, or even the entire catch, has consisted of N. modestus since an increase of this species has been reported from Korean waters by Korean scientists (Choi et al., 1982). However, since threadsail filefish had previously been the most common species among filefishes in the area, it is probable that some of the catch would have consisted of this species also.

There is a set-net fishery located in the central Pacific coast of Japan that clearly shows the remarkable increase in abundance of Navodon modestus (Figure 18). The increase was initiated by an extraordinarily large survival of 1968 and 1969 year classes (Kobata, 1981), and this was also observed in the Seto Inland Sea (Kakuda, 1980). It seems likely therefore that unusually favourable conditions for the survival of filefish may have occurred all around Japan during these two years. Details and overall statistics for the Japanese catch are not available. However, a large part of the catch has been taken mostly by trawl and set-net from almost the entire coast of Japan, except for the northernmost part - Hokkaido, (Kakuda, 1976, Shibata, 1981). The distribution of catches by set-net and trawl indicates the unusual demersal-pelagic nature of the fish. The commercial value of the fish in Japan is very low and the increase in stock resulted in what amounted to a rather unattractive catch for fishermen, market and processors (Kanagawa Prefecture, 1981). Seasonal changes in the catches and fishing grounds suggest that the fish has a fairly large migratory range. It is estimated that the total catch around Japan is now about several hundred thousand tons.

The catches by China and the Korea Rep. are mostly taken by trawlers (Chien et al., 1980, Choi, 1982). The state of exploitation of these fisheries is not known but the stocks are probably fully exploited as the total catch by both these nations has levelled off in recent years. Unlike Japan, there are no reports of fishermen from China or the Korea Rep. taking steps to avoid catching these fish.

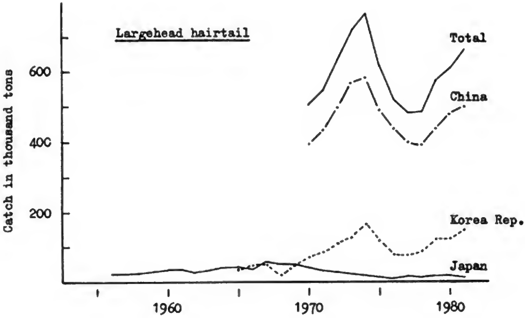


Figure 17. Catch of largehead hairtail by country from the Yellow Sea and East China Sea. See Appendix Table 10 (1: China, 2: Japan and 3: Korea Rep.) for statistics.

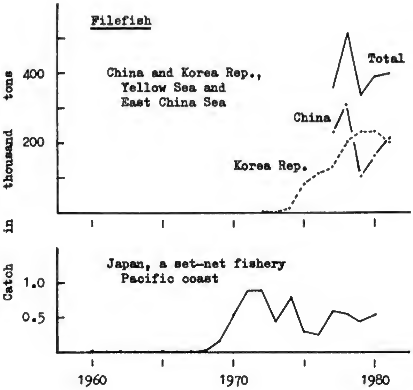


Figure 18. Catch of filefish by country from the Yellow Sea and the East China Sea and the catch by a Japanese setnet fishery in the central part of the Pacific coast of Japan. The data on the Japanese catch in the region is not available. See Appendix Table 10 (4: Filefish) for statistics.

The fish may be composed of many local stocks but with mixing throughout the life history especially during the early stage of life (Ikehara, 1977). The fish grow very fast, and attain 16-19 cm body length at age 1, 19-24 cm at age 2 and 24-33 cm at age 3, and mature at age 1-2 (Ikehara, 1976, Kakuda, 1978). A large change in the fat content was observed before and after the increase (Kakuda, 1980) which is indicative of a response to the change in density. However, the cause and initiation of the increase must have been due to an unusual combination of the physical and biological conditions since this was the first occasion in history when such an event had been recorded.

It has now become apparent that many demersal fish stocks in the Yellow Sea and East China Sea have been overexploited and that the current state of the stocks is such as to give rise to serious concern. Many scientific studies have concluded that fishing effort should be reduced to protect spawning stocks and that the mesh size of trawls should be increased to protect juveniles in the first instance and to increases production in the longer term. These studies estimate that many stocks should recover and provide substantially larger catches in 3-5 years, if regulatory measures can be effectively enforced (Ikeda, 1964, Ōtaki, 1964, Okada, 1974, Sato, 1974, Okada et al., 1972, Mio, 1977).

In Japan, since 1963 the mesh size in the offshore trawl fishery has been increased from 36 mm to 54 mm. However, this may have been insufficient and it is thought that a larger mesh of 70-80 mm would have been preferable for offshore fishing (Sato, 1974, Mio, 1977). It is not known what regulatory measures have been implemented in the other countries but there have been many published scientific reports recommending that similar actions be taken (Hwang, 1977, Kim, 1977, Liu et al., 1979).

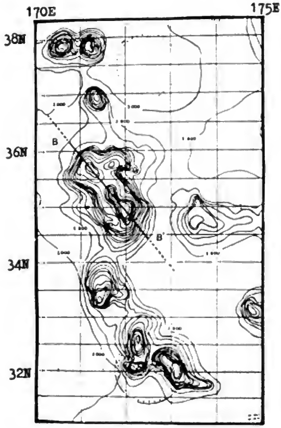
Lack of a multinational management strategy is another serious problem in the region. There have been two bilateral agreements between China and Japan and between Japan and Korea Rep., dealing with the regulation on fishing in the region. Both agreements provide for the closure of grounds for closed seasons, and for the limitation of the total number of trawl vessels in the joint regulatory areas. However, these arrangements are incomplete. Firstly, many of the resources dealt with in separate agreements also happen to be shared stocks that need to be dealt with together. Secondly the fishing by Korea, D.P. Rep. and Taiwan, the Province of China are entirely excluded. The early establishment of measures that reasonably reflect the resources and the fishing may be difficult to achieve for political reasons however. Nevertheless, the rational exploitation of the resources will not be possible without such arrangements. It seems likely that the total catch from the region could substantially increase if reasonable management measures could be implemented by all the nations concerned.

7.2.9 Demersal fish on the seamounts in the Central Pacific

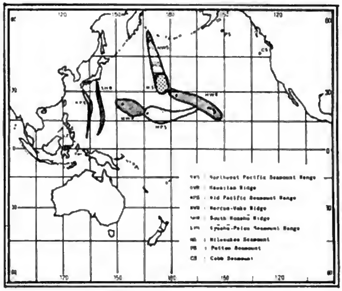
A number of "Guyot", seamounts with very flat summits, are located along the Northwest Seamounts Range (Emperor Seamounts) as was described in Section 1.4. Commercial trawl fishing was initiated by the USSR and Japanese fishery in the late 1960's on some seamounts around the southern tip of the Range where the summits are flat and suitable for trawling. These fall in the southeastern part of the area (Chikuni, 1970, 1971, Iguchi, 1973, Kuroiwa, 1973, Sasaki, 1973, 1978, 1984). The depth on top of those summits where intensive fishing has been carried out is generally 200-400 m. The topographic features of one of them are shown in Figure 19.

The major species harvested are pelagic armorhead, Pentaceros richardsoni Smith (80-90 percent) and alfonsin, Beryx splendens Lowe (2-5 percent) with incidental catches of ruftfish, Hyperoglyphe japonica (Doderlein), mirror dory, Zenopsis nebulosa (Temminck et Schlegel) and Japanese beardfish, Polymixia japonica Günther.

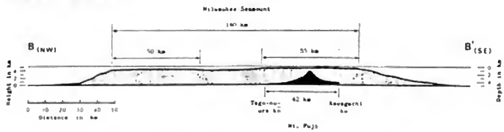
The Japanese catch of pelagic armorhead ranged from 20-30,000 t annually during the period 1972-76. During this period the catch-per-unit-effort decreased continuously to about 1/6th of the initial level (Sasaki, 1978). A catch quota has been imposed on the fishery on the southernmost part of the range since 1977 when the region was included in the national jurisdiction of the U.S.A. Because of this, the total annual catch of the fishery is now limited to 1,000 t including other fishes. Nevertheless, it is reported that the c.p.u.e. has remained at a low level (Sasaki, 1984). Details of fishing and catches by the USSR are not known. However, fishing was quite intense and the catch was probably quite large during the early 1970's when a fleet of 3-20 vessels comprising of 300-3,000 gross tons stern trawlers was frequently observed by Japanese research and commercial vessels (Kuroiwa, 1973). The exploitable fish on these seamounts appear, therefore, to have been heavily fished during the initial stage of exploitation. As a result the abundance is probably at a low level in recent years.



Submarine topography, contour in fath



Major Seamount Ranges in the North Pacific



A schematic profile along the section B – B'

Figure 19. Submarine topography, location and a schematic profile of the Milwaukee Seamounts in the Northwest Seamounts Range (Chikuni, 1971).

The Japanese catch of alfonsin increased substantially after 1979 with an increasing c.p.u.e. However, the c.p.u.e. has levelled off in recent years (Sasaki, 1984), and it appears that the fish on the seamounts are now fully exploited.

Pelagic armorhead and alfonsin on the seamounts show an extremely unique life form (Chikuni, 1970, 1971, Sasaki, 1974). The majority of the catch is taken from the top or slope of the seamounts. This is composed of large adult fish of 25-35 cm body length from the tops, and 20-40 cm length from the slopes. No younger/smaller fish are found there. Both species are reported to be distributed widely in the North Pacific Ocean, but details of the life history are unknown. It is quite interesting to note that the pelagic stages of both juvenile (12-13 cm body length) and adult (22-32 cm) pelagic armorhead were abundantly found in the surface to near-surface layers of the high seas in the Northeast Pacific (Honma et al., 1969, Chikuni, 1970). Many indivuduals are found in the stomachs of sei whales and many individuals have been caught easily by angling or by using scoop nets from the whaling vessels.

Further surveys and studies of the life history of these species are required not only in connection with their rational utilization but also as part of a general study of the marine science in the North Pacific Ocean. In this regard, an international workshop[1/] recently held on the environment and resources on seamounts may have established a signpost for the future.

7.2.10 Summary for demersal fish

Almost all the major demersal fish resources in the Northwest Pacific appear to have been intensively exploited as discussed above. The only exceptions are Atka mackerel and sandlances which do not appear to be fully exploited. However, even for these stocks significantly larger catches may not be expected in the future. It seems therefore that there are no more unexploited or underexploited resources in the area. In fact, it appears that since the summits of seamounts in the Mid-Pacific were first exploited by trawl fishing in the late 1960's, all exploitable grounds have been exploited.

The total demersal fish catch from the entire area is considerable, amounting to about 5.6-6.5 million tons of nominal annual catch (Table 5, Figure 3). The catch actually taken is estimated to be several hundred thousand tons higher than this when incomplete reporting is taken into account. The demersal fishery in the area has already gone through its development phase and rational management is needed in future to maintain production at a high level. In terms of quantities captured, Alaska pollack and largehead hairtail are the two most important resources (Table 7, Figures 8 and 17).

It is also important that appropriate management measures are enforced for those fisheries that exploit depleted stock. A decline in a number of commercially important fish in the Yellow Sea and East China Sea is particularly serious. Although there have been the two bilateral agreements, the management measures actually taken appear to have been inadequate as there has been no evidence so far of a recovery of the stocks. A comprehensive rebuilding plan, for both the coastal and offshore fisheries needs to be established and implemented following further studies. The establishment of a multilateral commission by all the nations concerned is the ideal way to achieve this but it may be extremely difficult to realize it in the immediate future due to the political complexity there. Some measures are, however, desirable, even if only undertaken by those nations that are willing to collaborate. Participation by other countries in the future might then follow as it is believed that there may be no nations prepared to deny the benefits and scientific rationale of resources management once the results of management have been demonstrated. The current total catch from the region is estimated to be about 1.5 million tons (Table 5-(3)). However, an additional several hundred thousand tons of commercially valuable species should be achieved with an appropriate management strategy.

1/ Informal Workshop on the Environment and Resources of Seamounts in the North Pacific. Shimizu, Japan, 21-23 March 1984, organized jointly by the Far Seas Fisheries Research Laboratory, Japan, the Southwest Fisheries Center Honolulu Laboratory, U.S.A. and the Japanese Society of Fisheries Oceanography. The proceedings of the Workshop will be published soon in both the Bulletin of the Japanese Society of Fisheries Oceanography and the Technical Memorandum Series of the U.S. Department of Commerce, NOAA, National Marine Fisheries Service.

Yellowfin sole in the Okhotsk Sea and Pacific ocean perch are also typically depleted stocks. The management of the former stocks is now almost entirely under the jurisdiction of the USSR while the latter is the concern of the U.S.A..

If effective management measures were adopted, and if a disastrous change in natural environment did not take place, especially for Alaska pollack, the total harvest from the entire area might reach or even exceed 7 million tons.

7.3 Coastal Pelagic Fish

The number of species in coastal waters in the Northwest Pacific that are utilized for human consumption is considerably smaller than that of demersal fish. For example, about 40-50 species are commonly observed in the fish market in Japan. However, the greater part of the catch is composed of five major species and these usually account for about 90 percent of the total coastal pelagic fish catch.

The nominal total catch of coastal pelagic fish from the entire area has nearly doubled during the past decade and exceeded 6 million tons in 1981 (Table 9, Figure 3). The catch surpassed that of

Table 9

Catch of pelagic fish by major species during 1970-81.1/

('000 t)

Species	1970	1975	1976	1977	1978	1979	1980	1981
Pacific herring	426	437	307	294	87	118	129	131
Pacific saury	163	317	188	343	460	364	238	203
Japanese sardine	17	530	1,077	1,471	1,934	2,156	2,595	3,614
Japanese anchovy	420	421	343	386	336	296	320	345
Chub mackerel	1,572	1,644	1.380	1,759	2,239	2,016	1,679	1,346
Japanese Jack mackerel	222	193	136	95	64	93	57	72
Other pelagic fish 2/	353	424	489	479	495	564	526	497
Total2/	3,173	3,968	3,920	4,829	5,617	5,608	5,544	6,208

1/ Catch by Korea D.P. Rep. is entirely excluded and the bulk of the Chinese catch is not included due to the incomplete species breakdown.

2/ In addition to the above, the total pelagic fish catch is generally underestimated due to the incomplete species breakdown, especially for the category "Other pelagic fish". This may have been included under the heading of "Miscellaneous marine fishes", in the statistics from other countries.

demersal fish in 1981 thus reversing a trend that started in the early 1940's when the herring and sardine catches declined drastically. The pelagic fish recovery has been particularly due to the abundance of mackerel stocks and to an increase in Japanese sardine in the early 1970's. The actual total catch is believed to be substantially larger than the nominal figures as the catch by the Korea D.P. Rep. is unknown and that for China has been reported for only three species, namely herring, Spanish mackerel and chub mackerel.

In this paper the eight major neritic resources, i.e. Pacific herring, Pacific saury, Japanese sardine, Japanese anchovy, mackerel - with two species combined, Japanese Jack mackerel, Japanese amberjack (yellowtail) and Japanese Spanish mackerel are reviewed separately. There is also a general discussion at the end of this sub-section.

7.3.1 Pacific herring, *Clupea pallasi* Valenciennes

Pacific herring is a typical boreal coastal pelagic fish distributed in cold water throughout the area. The majority of the stocks are therefore distributed along the northern coasts although there are also smaller stocks distributed further south where there happen to be cold water masses (sub-sections 2.3.2 and 2.4). These stocks are separated geographically into 10 groups. These are: (1) the Korfo-Karaginsk stock along the northeastern Kamchatka Peninsula, (2) the Gizhinsk-Kamchatka stock along the northeastern coast of the Okhotsk Sea, (3) the Okhotsk stock along the north and west coast of the Okhotsk Sea, (4) the East Sakhalin to Hokkaido Okhotsk stock, (5) the De-Kastri stock in the Tatarskii Strait and (6) the West Sakhalin to Hokkaido Japan Sea stock for the major northern stocks (Iizuka, 1974, Irie, 1980, Irie et al., 1979, 1982, Kobayashi, 1979, Morita, 1982, Takahashi, 1976), (7) Primorskiy stock, (8) the Peter the Great Bay stock along the west coast of the Japan Sea, (9) the East Korean stock along the east coast of the Korean Peninsula and (10) the Yellow Sea stock along the Chinese coast and the west coast of the Korean Peninsula for the southern smaller stocks (Kobayashi, 1979, Park et al., 1981, Grant et al., 1983, Zhu, 1980, Tang, 1980, Ye, 1980, Young, 1982). Many of these groups can be further sub-divided into local stocks with isolated spawning grounds but it appears that the mixing may be common throughout the life history between neighbouring local stocks, even between neighbouring groups. At the extremes of the range, the northernmost and southernmost two stocks, Korfo-Karaginsk and Yellow Sea stocks, appear to have been almost completely isolated from the other stocks due to the geographical and oceanographic conditions there. Morphological evidence confirms that the Yellow Sea stock is likely to be separate from others (Park et al., 1981). It is noted that there are many small local stocks distributed along the Pacific coast of Hokkaido and Honshu (Iizuka, 1974, Kobayashi et al., 1979).

As with other major coastal pelagic fish resources, the herring stocks in the area have shown considerable long-term fluctuations. The two stocks around northern Hokkaido; the East Sakhalin to Hokkaido Okhotsk and the West Sakhalin to Hokkaido Japan Sea stocks, once predominated and formed a single large stock in the region for about 50 years during the mid-1870's to the mid-1920's (Hanamura, 1963, Motoda et al., 1963, Iizuka, 1974). The size of the stock was then enormous and was the largest of the herring stocks, and probably the largest stock of any species, including demersal species in the area, at that time. The Japanese catch during this period had mostly come from the coastal set-net fishery and consisted mainly of spawning fish, yielding from 500-700,000 t annually. However, catch per unit effort and the catch began to decline around the 1930's, and apart from intermittent recoveries, due to occasional strong year classes, spawning fish had eventually almost disappeared from the waters around Hokkaido by the early 1960's. This resulted in a collapse of the herring set-net fishery (Figure 20, Appendix, Table 11). Associated with this decline, the stock had become separated into several smaller local stocks and the connection between the fish in the Okhotsk Sea and the fish in the Japan Sea had disappeared. The spawning grounds had, at the same time, shifted further north along with the disappearance of the southern spawning grounds (Hanamura, 1963, Motoda et al., 1963). A similar phenomenon was observed in the stocks along the west coast of the Japan Sea (Motoda et al., 1963). The reason for this drastic change in abundance and habitat is not clear. However, it has been generally accepted that a change in environmental conditions might have affected both the migration of the spawning fish and also the rate of survival of juvenile fish. A key factor may have been the warming of the sea and a change in climate that took place from 1932-38 and again more strongly after 1955 (Motoda et al., 1963). The abundance of the remaining fish which are distributed in several isolated local stocks, has been at a very low level in recent years and no sign of recovery has been observed so far.

The two stocks along the north and west coast of the Okhotsk Sea, Gizhinsk-Kamchatka and Okhotsk stocks had, until around the early 1950's, been traditionally harvested by the USSR coastal fisheries yielding about 30-50,000 t annually of mainly the spawning fish (Iizuka, 1974, Kobayashi et al., 1979). Since around the mid-1950's fishing intensified greatly in association with offshore fishing by purse-seine, gill-net and trawl. The total catch from these two stocks then increased rapidly and reached about 400,000 t during the late 1960's (Figure 20, Appendix Table 11). Of this the catch from the Okhotsk stock accounted for about 90-95 percent of the total catch from the Sea. The Japanese fishery started fishing these offshore stocks during the mid-late 1960's and caught about 50,000 t annually during the early 1970's. However, several regulations had been imposed on both the USSR and Japanese fisheries since 1970 and these included a complete ban on fishing the Gizhinsk-Kamchata stock. This followed an agreement at the 14th Session of the Japan-USSR Fisheries Convention in 1970, that these stocks had already been overexploited. The Okhotsk stock continued to decline even after the regulations had been enforced however, and fishing on this stock has been completely banned since 1977 (Figure 20 Appendix Table 11). The reason for this decline is not clear. It is interesting however to see the fact that the decline took place consecutively from the southeastern to the northern and western stocks in a regular counter clockwise direction. Kobayashi

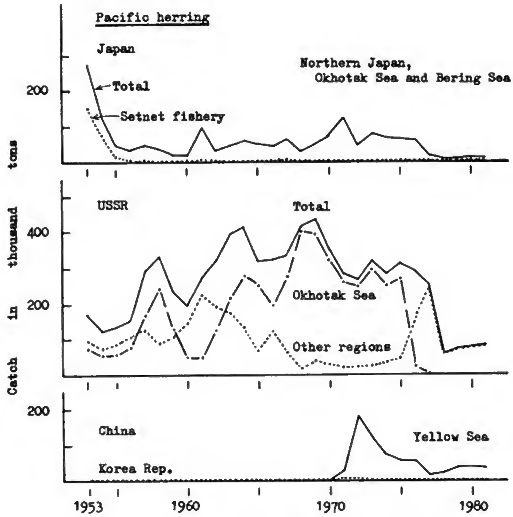


Figure 20. Catch of Pacific herring by country and region. The "Other regions" in the USSR catch include the Western Bering Sea, the Pacific coast of Kamchatka to the Kuril Islands and the Japan Sea. See Appendix Table 11 for statistics.

et al., (1979) suggested, in this connection, that an unfavourable environmental regime might have expanded from the southeast of the region around the coast and that a change in the Okhotsk Sea Gyre might have played an important role. However, it is quite likely that the large catches during the 1960's to mid-1970's would have accelerated the decline in the stocks. The stocks appear to have remained at a very low level in recent years and no sign of their recovery has been reported so far.

The Korfo-Karaginsk stock is considered to be a single and isolated stock from those in the Okhotsk Sea and the eastern Bering Sea. It is also one of the major stocks in the northern part of the area which once had been intensively exploited and subsequently declined (Iizuka, 1974, Morita, 1982). The process of the development of the fishery and the decline of the stock is quite identical to that of the stocks in the Okhotsk Sea. That is, there was an intensive fishery by the USSR coastal and offshore fisheries started in the early 1950's and subsequently, and offshore fishery by Japan in the early 1960's. The total catch by these fisheries attained 13,000-17,000 t during the period 1960-66 but declined sharply thereafter, associated with a decline in stock abundance. Commercial fishing has been completely prohibited since 1970, but there has been no evidence of an increase in abundance.

The De-Kestri stocks in the Tatarskii Strait, which are the smallest of the northern major stocks, had been stable until around the end of the 1960's with an annual yield of about 3-6,000 t from the USSR and Japanese vessels (Iizuka, 1974). The Japanese fishery has been prohibited from catching the stock since 1977 in connection with the extension of USSR jurisdiction. The state of the stock in recent years is not known.

No information is available for the Primorskiy and the Peter the Great Bay stocks which are two small stocks along the west coast of the Japan Sea. These two stocks may have stabilised at a low level since the nearest other small stock, the East Korean stock which inhabits the same hydrographic system, appears to have been stable at a low level (see below).

The nominal total catch reported from the Korea Rep. is composed of catches from the east coast (the Korean stock) and from the west coast (the Yellow Sea stock) in nearly equal quantities. They are taken incidentally by trawl and gill-net and no directed fishing has been attempted. Although the quantity is very small, a steady catch has been taken over the years (Figure 20, Appendix Table 11). The Korean stock appears therefore to have been stable at a low level throughout the years.

The Yellow Sea stock has been intensively exploited by the Chinese fishery and the catch by the Korea Rep. has been negligibly small (Figure 20, Appendix Table 11). The Chinese catch shows an abrupt increase around the early 1970's (Figure 20) but this is because the statistics before 1969 were incomplete and the stock has probably been exploited by local fishermen for many years. The Korea D.P. Rep. is believed to have exploited the same stock to some extent but no information is available. The Chinese catch is taken by various gears including both coastal and offshore trawls, purse-seines, coastal set-nets and stow-nets (Ye et al., 1980). The stock appears, therefore, to have been fully exploited. However, there is no evidence of a serious decline in abundance due to fishing, nor has there been a change in the location and extent of the spawning grounds (Young et al., 1982). This implies that this particular stock has not been affected by unfavourable environmental conditions, as has so commonly been observed for other stocks. The formation of the cold water masses in the region depends chiefly on the climate of the bordering continent rather than on local oceanographic complexities there, as was discussed earlier, and this may explain why this isolated stock has remained at a stable level. Another difference about this stock is that about 99 percent of the fish mature at age-2 (Tang, 1980). This is substantially younger than in the northern stocks where maturity is at age 4-6 in the Okhotsk stock (Kobayashi, et al., 1979), and at age 3-4 in the east and west Sakhalin-Hokkaido stocks[1/] (Iizuka, 1974).

As was discussed above many herring stocks have dropped to a very low level in recent years and this is particularly so for the major northern stocks from which several hundred thousand tons was harvested annually for many years during their prosperous period. Strict regulations have been imposed on the fisheries. However, it is unlikely that these stocks will recover in the immediate future since the major reason for their decline is believed to be environmental and there is no indication of a return to more favourable conditions.

It is interesting to note that there is a considerable overlap in the food organisms of herring and juvenile Alaska pollack in the northern Okhotsk Sea (Irie et al., 1982). For example, Euphausidae, Calanoidae and Amphipoda were commonly found in the stomach contents of both species and there may have been competition between them for these food species. It was also reported that the growth of herring around Hokkaido greatly varied in relation to changes in year class strength and the consequent variations in the size of the stock (Kitahama, 1955, Motoda et al., 1963). The amount of food and competition with other species, must therefore be considerably critical for herring stocks. The state of the Alaska pollack stocks in the Northwest Pacific during the prosperous herring period - 1875 to 1925 - is not known. However, it is notable that the Japanese Alaska pollack catch from the waters around Japan began to increase after the decline of the Sakhalin-Hokkaido stock of herring and that the USSR Alaska pollack catch from the Okhotsk Sea had markedly increased during the declining period of the two herring stocks there. Both species have attained a pelagic-demersal combined life form. It is quite possible therefore that competition between the two may have played an important role in the relative changes in their abundance, not only for food but also for living space. Further studies of herring stocks, environmental conditions, and inter-specific relationships, are strongly recommended.

7.3.2 Pacific saury, Cololabis saira (Brevoort)

Pacific saury is widely distributed in temperate waters extending from coastal waters to the northern central Pacific Ocean, although the main concentrations are limited to coastal regions. There are three stocks in the area. These are: (1) the Northwest Pacific stock along the Pacific coast of Japan, (2) the Japan Sea stock and (3) the Central Pacific stock. The first two of these

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1/ Age 4-5 during its prosperous period, and the maturation had been fostered during the declining period (Motoda et al., 1963).

have been intensively exploited while the third which extends beyond the eastern border of the area has never been commercially exploited (Japan, Fisheries Agency, 1973a). The total catch from the two stocks has been quite large as a single species catch, ranging 160-460,000 t annually (Table 9).

The fish form many large schools and migrate seasonally, travelling long distances to the north in the summer and to the south in the winter. The fish prefer oceanographic conditions associated with the convergence of cold and warm sea currents where sharp thermal fronts develop. They concentrated in association with these conditions, forming dense schools which enable fishermen to catch them effectively. Such concentrations occur along the northeast coast of Japan to the southern Kuril Islands where the Oyashio and Kuroshio converge and along the southeast coast of the Korean Peninsula where the Liman Current and branches of the Tsushima Warm Current converge.

The Northwest Pacific stock has a large biomass. It is distributed along the Pacific coast of Japan and extends to offshore waters (Japan, Fisheries Agency, 1973a, Odate, 1977, Odate et al., 1980). Spawning grounds appear to be concentrated in coastal waters along the south and west coast of Japan. Larvae are dispersed, and large numbers have been observed offshore. It seems likely therefore that spawning takes place over a wide area but the details of possible offshore spawning are not well known. Major spawning in coastal waters takes place twice a year, from January to April in southern and western waters (Japan, Fisheries Agency, 1973a, Odate, 1977, Odate et al., 1980) and from July to November in northern waters (Japan, Fisheries Agency, 1973a, Odate, 1977). However, if minor spawnings are included, spawning appears to extend almost all-the-year-round at some place or other. The growth of the fish is very fast and the age at first maturity is quite young. They grow to about 15 cm body length by the beginning of age-1. Mature females are observed at about age 1.5 while all fish are mature by age-2. Fish at age-3 disappear almost completely from the exploitable stock which suggests the very short lifespan.

Annual catches show large and irregular fluctuations and range from 60-580,000 t (Figure 21, Appendix Table 12). The Japanese catch, which accounts for about 80 percent of the total, has been taken mostly from along the northern Pacific coast of Japan and partly from along the Kuril Islands. In this latter region, a catch quota has been imposed on the fishery by the Japan-USSR Fisheries Convention. The USSR catch is probably taken mostly from waters under its own jurisdiction and partly from the Japanese fishing zone where a catch quota has been imposed on the fishery by the USSR-Japan Fisheries Convention.

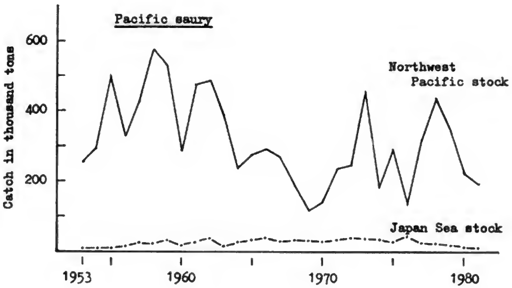

Figure 21. Catch of Pacific saury by stock during 1953-81. See Appendix Table 12 for statistics.

Around 1950, the Japanese catch increased markedly in connection with the development of light lured stick-held dip-net fishing from a level of about 10,000 t to 200-500,000 t (Japan, Fisheries Agency, 1973a, Fukushima, 1979). The fishery has been based on feeding fish migrating to the north along the central to northern Pacific coast of Japan during August to November[1/] taking benefits from the shoaling nature of the fish. The annual fluctuation in the catch seems to have been mainly due to variations in the availability of fish schools caused by changes in their migratory routes and degree of agregation rather than to changes in stock size. Complex and significant relationships have been observed between changes in the oceanographic conditions of the Oyashio and Kuroshio and the availability of the fish, for example, formation of fishing grounds, the nature and size of schools, the location and distribution range of fishing grounds, etc. (Fukashima, 1979, Aizawa, 1978, Hotta et al., 1970). The relative abundance index of the stock suggests that the stock has been fairly stable over the years (Kurita et al., 1973, Tanaka, 1983), although it does change substantially from season to season, (Tanaka, 1983). However, a long-term change in the level of total biomass has been observed. Namely the abundance of the entire stock appears to have levelled down since around the mid-1960's (Figure 21, Appendix Table 12) which will be discussed later in conjunction with the changes in dominancy in the pelagic fish community around Japan.

A detailed assessment of the Northwest Pacific stock is difficuit to make due to the complexities referred to above. However it appears that the exploitable stock, excluding fish distributed offshore further to the east, has been nearly or fully exploited and that the recent status of the stock is probably at a lower level than during its prosperous period. There is no evidence so far that the spawning stock has been depleted by fishing (Tanaka, 1983), and a further drastic decline in stock abundance is not likely to be caused in the future by fishing, for the reasons mentioned above.

The Japan Sea stock is considerably smaller than the Northwest Pacific stock. The major spawning ground is located in the southwestern part of the Sea along the east and south coast of the Korean Peninsula while minor spawning is observed in the northern regions along the Japanese coast (Japan, Fisheries Agency, 1973a), and the major spawning takes place during April to June though the larvae are found almost all-the-year-round (Jo, 1977, Shon et al., 1977). The fish migrate over a wide area, to the north in summer and to the south in winter (Gong et al., 1977) and appear to be separate from the fish of the Northwest Pacific stock apart from a minor overlap between the two stocks at the southern and northern fringes of their distributions (Japan, Fisheries Agency, 1973a).

These fish are largely exploited by the Korean Rep. fishery and the Japanese catch from the stock has been negligibly small amounting to only 3-5,000 t annually in recent years (Figure 21, Appendix Table 12). It is believed that the Korea D.P. Rep. and the USSR also exploit these fish but no details are known. The oceanographic conditions for good fishing are identical to those for the Northwest Pacific stock. In this instance however, the location is off the east coast of the Korean Peninsula where sharp thermal fronts are developed in assocation with the convergence of the cold Liman Current and the Tsushima Warm Current (Gong et al., 1974). A feature of this fishery is that peak fishing occurs regularly twice a year, once in March to July when about 70 percent of the catch is taken and once in October to February when about 30 percent is taken. The Korean Rep. catch has been taken mostly by surface drifting gill-net, and this makes up about 90 percent of the total catch. The fishing effort in units of numbers of gill-nets expended, increased markedly around 1965 and has been kept at a high level thereafter. The c.p.u.e. declined in connection with this expansion of fishing effort, however, and has remained at almost the same level since then (Gong et al., 1977), which resulted in the same level of the total catch throughout the years (Figure 21). It is a clear contrast to the Northwest Pacific stock that the catches from the Japan Sea stock do not show significant annual fluctuations. Concentration of fishing on spawners, especially in the spring, is one of the peculiar natures of the exploitation. These features may have supported the fishery to maintain a relatively stable catch in conjunction with less diversity in oceanographic conditions and a limited fishing/spawning ground there. The stock, taken as a whole, appears to be fully exploited and a further increase in the total catch may not be expected in the future. Although the spawning age of saury is quite young, age-1.5 to 2, the dependency of the fishery on spawning fish should be kept in mind for management purposes. Studies, particularly of the stock/recruitment relationship, are urgently required in the immediate future.

In conclusion, the exploitable saury in both the Pacific Ocean and Japan Sea in the area seem to have been fully exploited and management is unlikely to increase the total catch. That is to say an increase in the rate of exploitation of those fish is probably beyond the capabilities of mankind. Long-term large changes in the abundance of the stock also appears to have been caused chiefly by natural factors.

1/ Fishing has been prohibited in Japan during January to July to protect the major spawning fish in southern and western waters.

It is interesting to note the relationships between the vertical distribution of saury and their food habits. The larvae drift in the top 20 cm of the sea, without any diurnal movement (Odate et al., 1977). As they grow, they change their habitat vertically moving deeper to 15 m in the day and being at the surface at night, (Odate et al., 1977, Wada et al., 1982). Saury feed on zooplankton but change their species preference as they grow (Odate, 1977). For example, although saury change food as they migrate to the north and south, they only eat those zooplankton that move vertically and diurnally within the surface layer of the sea. Other species are not utilized even if they are abundantly distributed in the mid-deep layers of the sea (Taka et al., 1980). More surprisingly, although it appears that saury feed intensively on a particular copepod, Calanus plumchrus in daytime when they migrate to the northern-most region of their migratory range they select only the IV- and V- stages of the copepod and they do not eat the II- or III- stages even though these are quite abundantly available (Taka et al., 1982). These facts show the important role of just a few species of zooplankton in the survival and development of saury.

It is also reported that there is a competition for food between the larvae and fry of saury and those of Japanese snipefish, Macrorhamphosus scolopax, lanternfishes, Myctophidae, striped mullet, Mugil cephalus, yellowstriped butterfish, Labracoglossa argentiventris and greenling, Hexagrammos otakii. The first two in particular seem to be highly competitive (Odate, 1977). It is also well known that juvenile and adult saury are important food items for piscivorous animals such as porpoise, tunas, salmons, mackerels, sharks and Japanese flying squid (Japan, Fisheries Agency, 1973a). Saury appear therefore to be exposed to various competitors and predators throughout their lifespan. Further information on the factors affecting natural mortality is therefore essential in the future.

7.3.3. Japanese sardine, Sardinops melanosticta (Temminck et Schlegel)

Japanese sardine is widely distributed in the warm waters around Japan where the Kuroshio (Pacific Ocean) and Tsushima Warm Current (the Japan Sea) prevail. This species exhibits dramatic changes in its stock abundance. For example, it was recorded that the sardine fishery in Japan had repeatedly experienced a good catch period since the 1870's (Uda, 1952, Ishigaki et al., 1959, Nakai, 1962, Ito, 1961, Watanabe, 1983). A typical change in stock abundance is shown in Figure 22 and Appendix Table 13 for the period since 1910. Even if the period is limited to the past decade, a striking change in abundance is clearly shown (Table 9). During this period the catch increased from about 20,000 t to 3,600,000 t, an increase of more than 200 times. The catch in 1981 is the largest recorded for all species in the Northwest Pacific and exceeds the catches of other species including Alaska pollack (Tables 7 and 9).

Japanese sardine around Japan seem to be composed originally of several local stocks with isolated spawning grounds. However substantial mixing would presumably have occurred between neighbouring stocks especially during the early stages when the larvae were being transported by sea currents. An outstanding feature of this species is that it changes its distribution, spawning grounds and stock structure, in response to changes in the environment and in stock abundance. During the recent period of low catches, from the 1950's to the 1960's, four stocks were identified. These are: (1) the Pacific stock along the central to northern coast, (2) the "Ashizuri" stock along the southernmost Pacific coast, (3) the "Kyushu" stock along the west and north of Kyushu to the western Japanese coast of the Japan Sea and (4) the Japan Sea stock along the central to northern Japanese coast (Yamanaka et al., 1957, Ito, 1961, Japan, Fisheries Agency, 1973b). During the so-called "Great Catch Period" in the 1920's-1930's however, the "Kyushu" stock predominated over the others with a huge spawning ground further south, around the southwestern tip of Kyushu (Ishigaki et al., 1959, Ito, 1961, Nakai, 1962). Eggs and larvae were transported to the east and north over wide areas both along the Pacific and Japan Sea coasts of Japan. The juvenile and adult fish of the predominantly strong year-classes migrated seasonally to north and south along both coasts (Ito, 1961, Nakai, 1962, Watanabe et al., 1980). Stock identity was lost and there was a mixing with local stocks which had smaller spawning grounds along the northern coasts. The distribution range and the exploitable grounds were greatly expanded during this period to the southern Sakhalin coast in the north and the eastern Korean Peninsula to Primorskiy coasts in the west where a cold water system generally prevails (Figure 22, Appendix Table 13). With the drastic decline in abundance during the early 1940's however, the stock became divided into the above-mentioned four stocks.

Spawning grounds have, at the same time, also subdivided into several smaller local grounds accompanied by changes in location further east in the Pacific Ocean and north in the Japan Sea. The huge spawning ground around the southern tip of Kyushu, which had been the major source of the large recruitment to both the Pacific Ocean and the Japan Sea, disappeared (Nakai, 1962, Watanabe et al., 1980).

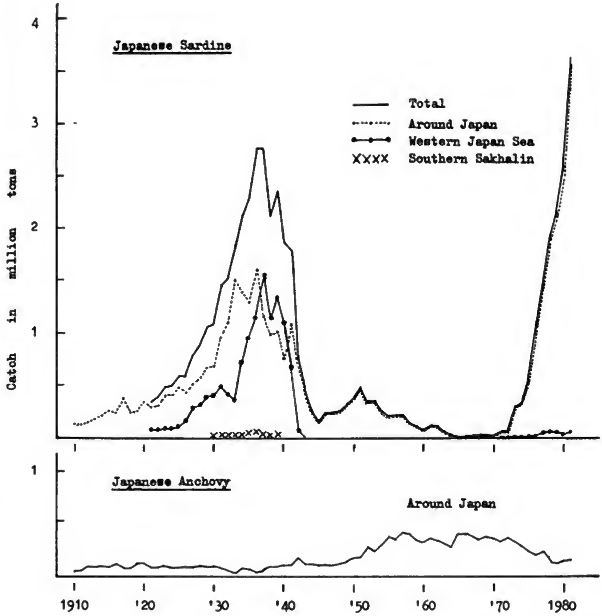

Figure 22. Catch of Japanese sardine by region and Japanese anchovy around Japan during 1910-81. See Appendix Table 13 for statistics.

The total catch during the "Great Catch Period" by all nations ranged from 1 to 2.8 million tons (Figure 22, Appendix Table 13). These fish were intensively exploited by Korean[1/] and USSR vessels in the western and northwestern Japan Sea where catches were nearly equivalent to those from the waters around Japan during the later half of the 1930's. The total catch, however, declined drastically since 1942 and 1965 marked the lowest catch with only 9,000 t. This resulted from the collapse of the stock and eventually from the collapse of the fishery which changed to fishing for the other pelagic fish species.

There is no doubt that stock abundance rapidly and strikingly increased during the 1920's to the early 1930's (Nakai, 1962), but the reason for this is not known.

The reasons for the collapse during the 1940's also remains a mystery although a number of studies have been made. It now seems to be accepted, however, that unfavourable changes in environmental conditions rather than over-exploitation had been the main cause of this drastic decline. A change in oceanographic conditions along the Pacific coast of Japan for example appears to be the most likely explanation (Nakai, 1949, 1962). It is possible that a change in the course of the Kuroshio along the Pacific coast of Japan during the late 1930's, due to the appearance of a large cold water mass off the central Pacific coast (see the sub-section 2.1.1 in this paper), caused the majority of eggs and larvae to be transported far from the coast to an area where feeding conditions for larvae was extremely poor. This could have resulted in a rapid decrease in recruitment and eventually a sharp decline in the spawning stock. A similar phenomenon was again observed in the case of the "Ashizuri" stock in 1963 when the stock abundance was further depleted (Nakai et al., 1967). It was also assumed that oceanographic anomalies may have altered the timing and location of spawning.

Whilst these explanations may appear to be reasonable, there is no justification for extending this hypothesis to fish which migrate into the Japan Sea where the spawning stock should not have been affected by the anomalies occurring in the Pacific Ocean. It is interesting to note, in this regard, a recent study dealing with the density-dependent factors in connection with changes in the abundance of Japanese sardine and Japanese chub mackerel (Watanabe, 1983). Negatively acting density-dependent factors may have affected reproductive potential even if density-independent factors initiated the decline in the first place.

Another possibility concerns the affect of predation by carnivorous plankton on the rate of fish larval mortality (Kawai et al., 1983). It is assumed that carnivorous plankton such as Medusae, Polychaeta, Chaetognatha and Amphipoda may have increased in numbers at the time of the spawning season of the dominant pelagic fish due to some perturbation.[2/] This could have led to a sharp decline firstly in recruitment and eventually in spawning stock. It is likely that both hypotheses are applicable to the other pelagic fish species and may help to explain the changes in the abundance of various pelagic fish. This will be discussed in further detail in a later section in this paper.

The Japanese sardine has, interestingly, increased again since the early 1970's (Figure 22, Appendix Table 13). The recent catches which have exceeded even the catches during the "Great Catch Period" have come, more significantly, only from the waters around Japan, and specifically from the "Ashizuri" stock along the Pacific coast of Japan (Watanabe, 1983). If the fish follow a similar migratory path to that followed during the 1920's-1930's (Figure 22), this increase should expand to the western Japan Sea. This is quite possible as the abundance of sardine and the spawning stock along the south and east coasts of the Korean Peninsula has been steadily increasing in recent years (Kim et al.,1980, Kim et al., 1981, Park et al., 1981). This is probably due to an expansion of the "Kyushu" stock to the north. The Korean Rep. catch has as a result been steadily increasing in recent years (Figure 22, Appendix Table 13).

The cause of the increase, like that of the collapse, remains a mystery. Analysis of the abundance of eggs and larvae shows clearly that since 1972 there has been a fairly good survival at an early life stage, and this has resulted firstly in a substantial increase in the spawning stock and secondly in a remarkable increase in the number of eggs spawned 2-6 years after a good year class (Watanabe, 1983). The stock has attained a huge biomass repeating such reproductive cycles in successively few years. The Pacific stock further north has followed a similar sequence a few years later (Watanabe, 1983) and it is expected that it will be so with the "Kyushu" and the Japan Sea

1/ Before the nation was separated into two countries.

2/ Kawai et al., (1983) estimated this would have been, again, the dynamic change in the Kuroshio route.

PHOTOGRAPH 4. An enormous haul of Japanese sardine by a large scale setnet fishery owned by the Manazuru-cho Fisheries Cooperative, Sagami Bay, central Pacific coast, Kanagawa prefecture. The catch exceeded 100 tons, which clearly shows the extraordinarily large increase in sardine stocks around Japan.

Photograph taken by Y. Hondo (Yamaha Motor Co. Ltd., 1984a).

stocks in the near future. However, it is not known why there was such an extraordinarily good survival of the 1972 year-class, since the larvae came from a very low level of spawning. There may be no doubt that environmental conditions must have favoured larval survival as was discussed by Watanabe (1983). However, there is no direct evidence for this. There may have been some subtle changes in the environment, too small to be detected by the oceanographic and biological monitoring. It is possible that positive density dependent factors, especially those on enhancing reproductive potential might have made the stock ready to increase during the depleted period, (Watanabe, 1983). A large decrease in predatory plankton might also have contributed to good survival at the larval stage (Kawai et al., 1983). After all, it seems reasonable to assume that there was a decline in carnivorous planktons at the time when sardine spawning declined.

Associated with the decline in particular specific fish species there have been changes in dominance (Figure 29, Appendix Table 19). For example, sardine replaced herring in the late 1920's and surpassed others until the early 1940's. The dominancy then switched to saury, Jack mackerel and Japanese chub mackerel in turn. The sardine has again dominated over the other species in recent years. Competition for space and food must have played an important role in these changes, and this will be discussed further in the last part of this section.

When they are in an ascending phase the sardine stocks appear to grow extremely rapidly and provide very large catches. When they decline they also change very rapidly. Although the major causes of these dramatic changes are probably natural rather than due to fishing, a management strategy is required when the stock is declining. This is to conserve the spawning stock and to maintain reproduction at a safe level. This should help to slow down the rate of collapse on the one hand and to hasten recovery on the other.

7.3.4 Japanese anchovy, Engraulis japonica (Houttuyn)

Japanese anchovy is widely distributed in coastal waters along the entire coast of Japan and the southern Korean Peninsula. These fish prefer more inshore waters than other coastal pelagic fish. However, the distribution range of the species can be quite large as larvae and adult fish have been occasionally caught in the stomachs of skipjack caught 3-400 miles off the northern Pacific coast of Japan where the Kuroshio Extension prevails (Kondo, 1966). The vertical distribution is also very large as the fish are often caught by both the surface and bottom gears. These facts clearly indicate the eurythermal and euryhaline nature of the fish, although it is said that the fish do not occur south of the Kuroshio (Hayasi, 1961).

Anchovy around Japan are geographically grouped into four separate stocks (Hayasi, 1961, Kondo, 1966, 1969). These are: (1) the Honshu Pacific stock along the central to northern Pacific coast of Japan, (2) the Kyushu Pacific stock along the southwestern coast and in the Seto Inland Sea, (3) the West Kyushu stock along the west coast of Kyushu to the western Japan Sea coasts and (4) the Japan Sea stock along the central to northern Japan Sea coast. However, each of these stocks is considered to be composed of several local groups with different spawning grounds. Another feature of this species is that the fish spawn almost all the year round with major peaks in spring (April to June), summer (July to August) and autumn (September to October), and the fish spawned in each peak season form a seasonal brood. It appears that the stocks are mixtures of many local groups and seasonal broods and that the intermingling among them, even between neighbouring stocks, may commonly take place. Each of the seasonal broods in the above-mentioned four major stocks is dealt with as a unit for practical purposes (Hayasi, 1961, Kondo, 1966, 1969, Takao, 1964, Takao et al., 1975).

The historical catch record shows a large increase in the anchovy catch since the 1950's from about 100 000 t level to 300-400 000 t (Figure 22, Appendix Table 13), although the reason for this increase is not known. However, it can be noted that the increase in abundance of anchovy occurred during the period of decrease in Japanese sardine (Ito, 1961, Hayasi, 1966). The decline in sardine stocks may have favoured anchovy in terms of better availability of space and food. In fact, an historical catch record of a set-net fishery on the central Pacific coast of Japan shows larger catches of anchovy when sardine catches declined (Ito, 1961). A similar phenomenon has also been observed in the Seto Inland Sea (Ito, 1961). An intensification of fishing during the period, and a change in target species from depleted sardine stocks to abundant anchovy stocks, has also contributed to larger catches. Changes in other environmental conditions may not have been so important for anchovy as for sardine, when the tolerant nature of anchovy is taken into account. The recent decline in catch since the mid-1970's may have been due firstly to a decline in abundance in association with an increase in sardine stocks and secondly to a change in species preference by fishermen (Figures 22 and 23).

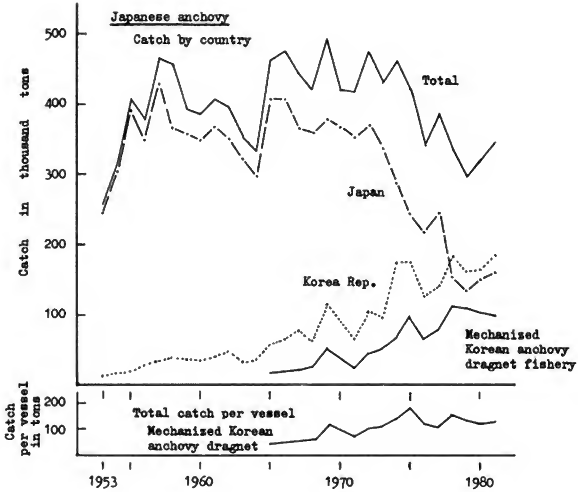

Figure 23. Catches of Japanese anchovy by country during 1953-81 with changes in fishing efficiency of the anchovy dragnet fishery in the Korea Rep. during 1965-80. See Appendix Tables 14 (1: catch) and (2: fishing intensity of Korea Rep. fishery) for statistics.

During the 1950's to the early 1970's the Japanese catch of anchovy remained at a high level of about 300-400,000 t annually but rapidly declined thereafter to about 150,000 t in recent years (Figure 23, Appendix Table 14(1)).

The catch has been taken mostly from the Honshu Pacific stock (about 40 percent of the total) and the Kyushu Pacific stock including the Seto Inland Sea (about 30 percent). It is notable that about more than 20 percent of the total catch has been taken from the narrow and shallower Seto Inland Sea[1] (Hayasi, 1966). The catch from the Seto Inland Sea has been prominent as a single species accounting for about 25 percent of the total catch in the Sea which clearly indicates the strong neritic nature of the fish (Takao, 1964, Tatara, 1981).

The catch by the Korea Rep., which depends mostly on the West Kyushu stock, has shown a steady increase throughout its history (Figure 23, Appendix Table 14(1)). In contrast to that of Japan the increase during the past decade is striking, the catch having risen from about 60,000 t to 180,000 t. The nominal statistics of catch and effort show clearly that this increase in catch of the Korea Rep. has been due to an improvement in fishing efficiency especially in that of the anchovy dragnet fishery (Figure 23, Appendix Table 14(2)). The degree of mechanization and the size of engine have markedly increased during the past 15 years while at the same time non-mechanized vessels have disappeared over the period, the catch per mechanized boat has increased 2 to 3-fold. In spite of the large increase in the Korean catch, the size of the West Kyushu stock appears to have declined in recent years, as in the case of the two Pacific stocks. At the same time the catch of Japanese sardine has been steadily growing as was discussed in the previous sub-section. The Korean Rep. catch may now be levelling off and is expected to decrease in the near future.

A particular feature of the exploitation of anchovy is that the post-larval (15-35 mm body length) and juvenile (35-50 mm) stages have been intensively harvested in Japan by the "Shirasu (post-larval) fishery" comprised mostly of boat-seines. The total catch is equivalent to about 10-30 percent of the Japanese catch of adult anchovy (Appendix Table 14(1)). The number of individuals harvested during the "Shirasu" stage is therefore much greater than the number of adults harvested. For example, the average body weight is estimated to be 0.25 g for "Shirasu" and 7.5 g for adult fish. The total catch in 1981 is 161,000 t of adult fish and 53,000 t of "Shirasu"[2] catches. The numbers caught are therefore estimated to be 21.5×10^9 for the former and 212×10^9 for the latter. The lifespan of Japanese anchovy is only two to 2½ years at the most (Hayasi, 1961, Kondo, 1969, Japan, Fisheries Agency, 1973b) but the fish is therefore exposed to exploitation throughout almost its entire short lifespan.

Another notable feature is the importance of anchovy as a prey for piscivorous fish (Mitani, 1958, Hayashi *et al*., 1960, Yokota *et al*., 1961, Yokota, 1963, Tatara, 1965). The larvae and post-larvae of anchovy are intensively eaten by Pacific round herring, the fry and juveniles are eaten by mackerels, Jack mackerel, scads and yellowtail, while the juveniles and adult fish are eaten by mackerels, yellowtail, skipjack, tunas and various demersal fish. It was estimated that the quantity of anchovy eaten by demersal fish such as lizard fish, daggertooth pike-conger, hairtail and barracuda along the southern Pacific coast of Japan far exceeds the catch of anchovy of 25-35,000 t by the coastal fishery (Japan, Fisheries Agency, 1969). The situation is probably more severe in the Seto Inland Sea where both prey and predator are numerous, and confined to shallow enclosed waters (Hayashi *et al*., 1960, Tatara, 1965).

The total mortality of Japanese anchovy due to natural predation as well as fishing is therefore considered to be extremely high throughout their lifespan. Nevertheless, this is the only species, among the coastal pelagic fish, which has not experienced a drastic decline in stock abundance. The stocks around Japan have always been large enough to provide adequate recruitment for the next generation (Japan, Fisheries Agency, 1969, Takao, 1975, Watanabe, 1977) even though the catch has been accompanied by annual fluctuations mostly by changes in availability of fish.

The tolerant nature in many ecological features of the fish as discussed previously may have undoubtedly supported the stock in keeping its stability. In fact, the affect from the large oceanographic anomaly along the Pacific coast of Japan in 1963, which further depressed the declining sardine stocks as discussed in the previous sub-section, was limited to only a delay in major spawning seasons which did not hamper reproduction of the stocks so much as the fish usually spawn almost all the year round (Nakai, *et al*., 1967). A mathematical analysis of fishing mortality on the population parameters of the fish revealed there may be almost no risk to the stocks of anchovy being overexploited even if heavy fishing is attempted on them (Tanaka, 1983a).

1/ Total area: 18,700 km^2, mean depth: 33 m, water volume: 610 km^3 (Tatara, 1981).

2/ "Shirasu" includes a small amount of post-larvae of Japanese sardine and other fish but mostly comprises Japanese anchovy.

PHOTOGRAPH 5. An encouraging haul of Japanese anchovy by the day-time operation of a boat-seine of the Tokushima-shi Fisheries Cooperative, Kii channel at the eastern entrance of the Seto Inland Sea, Tokushima City. The operation is carried out by a pair of seiners with 9-14 GRT class vessel and a transportation boat with 5-10 GRT.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1983a).

Dried adult fish "KATAKUCHI-NIBOSHI" 8-10 cm length 8 months to 1 year old.

Dried post larvae "CHIRIMEN-JAKO" or "SHIRASU-BOSHI" 1.5-2.5 cm length 1-2 months old.

Packed products:
Left: "NIBOSHI"
Right: "SHIRASU-BOSHI"

PHOTOGRAPH 6. Dried products of Japanese anchovy, adults and post larvae, both used as food and as a high quality flavour for stocking.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1983a).

7.3.5 Mackerels, Scomber spp.

Mackerels occurring in the area consist of two species, Japanese chub (common) mackerel, Scomber japonicus Houttuyn and spotted chub mackerel,[1/] S. australasicus Cuvier, and both species inhabit the waters around Japan to the East China Sea. The distribution of these two species overlaps especially in the southern part of the region. Japanese chub mackerel prefer cooler waters and are distributed further north while spotted chub mackerel inhabit more southern and warmer waters. The two species are usually combined in the nominal catch statistics as the external differences are very slight and it is difficult for fishermen to separate these two species. The abundance of the common mackerel has been far greater than that of the spotted chub mackerel. The catch of spotted chub mackerel by the Japanese fisheries has made up only a small proportion of the total mackerel catch, usually less than 5 percent in the northern region and 15-25 percent in the south. The state of species identification in the waters further south along the Chinese coast is not well known.

Japanese chub mackerel around Japan consist of three major stocks. These are: (1) the Pacific stock along the Pacific coast, (2) the West Kyushu stock along the west coast of Kyushu and (3) the Tsushima Warm Current stock along the Japan Sea coast. Each of these can be further subdivided into several local groups (Usami, 1973, Japan, Fisheries Agency, 1973b). Several local stocks have also been identified in the western and southern part of the East China Sea (Usami, 1973, Ouchi et al., 1979), but these are grouped into the Western East China Sea stock in this paper. Not much is known about the ecology of these stocks. It has been reported that the Japanese chub mackerel that are abundantly distributed in the northwestern South China Sea along the Chinese coast are comprised of different stocks from those which have been intensively harvested by the Chinese fishery in recent years in the East China Sea (Zhu, 1980, Zhang, 1980, Wang et al., 1983). However, there is some doubt about the identity of these fish as it has not been confirmed whether they are S. japonicus or S. australasicus or a mixture of both.

Around Japan, Japanese chub mackerel is a typical neritic pelagic species that exhibits long-term fluctuations in stock abundance. The abundance of the Pacific stock, which is the largest among the stocks in the area, increased strikingly during the early to mid-1960's (Watanabe, 1970, 1977, Kawasaki, 1971). The Japanese catch from this stock increased during the period to reach 500-700,000 t annually, and this accounted for about 60-70 percent of the total Japanese catch from all the stocks around Japan in the late 1960's.

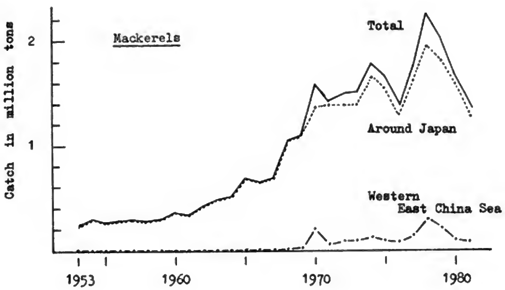

Figure 24. Catch of mackerels by region during 1953-81. The majority of the catch, about 95 percent, comprises of Japanese chub (common) mackerel but includes "Goma"-mackerel, see text for details. See Appendix Table 15 for statistics.

1/ "goma-mackerel" in Japanese.

The West Kyushu and the Tsushima Warm Current stocks followed a similar sequence a few years later (Iizuka et al., 1983). Namely, the Japanese catch from the West Kyushu stock[1] increased rapidly from about 50-70,000 t to 200,000 t and more during the period from the late 1960's to the early 1970's.

The total Japanese mackerel[2] catch has been at a very high level of about 1.0-1.6 million tons during the past 15 years following the above-mentioned large increase in stock abundance (Figure 24 and Appendix Table 15). The catch by the Korea Rep. fishery, which depends mostly on the West Kyushu stock and partly on the Western East China Sea stock, has also substantially increased since the late 1960's (Appendix Table 15). It should be noted that there was a substantial improvement in fishing efficiency during the period from the 1960's to the early 1970's in Japan and more recently in the Korea Rep. In Japan well equipped, medium-sized one boat purse-seiners have almost taken over from the traditional fishing gears such as hook and line and two-boat purse-seine. Improvements in the Korean Rep. fishery have also occurred with larger fishing boats and bigger engine-power, as discussed previously. These changes have undoubtedly contributed to the increase in catches although the principal reason for the increase in catches has been the increase in stock abundance.

The USSR catch, which has been quite large in recent years with an annual catch of 200-250,000 t (Appendix Table 15), is taken mostly from the Pacific stock along the Japanese coast. A catch quota is imposed annually on this fishery, following the USSR-Japan Fisheries Convention.

Mackerel catches from the western East China Sea and the northwestern South China Sea have been taken mostly by China. These have been at a relatively low level and have fluctuated considerably (Figure 24, Appendix Table 15). The majority of the catch from the northwestern East China Sea is probably Japanese chub mackerel depending mostly on the western East China Sea stock and to a lesser extent on the West Kyushu stock. However, the catches from the southern part of the East China Sea and the northwestern South China Sea consist of a mixture of species or may even be dominated by spotted chub mackerel for the reasons mentioned in the earlier part of this sub-section. It is interesting to note in this connection, that the catch taken by the Japanese purse-seiners in the east and southeast East China Sea along the Ryukyu Islands, where a warm water system prevails, consists of 40-70 percent of spotted chub mackerel (Iizuka et al., 1983). It can also be noted that the total catch of spotted chub mackerel by the Japanese fishery in the East China Sea has remained at a fairly stable level of 50-60,000 t annually in contrast to that of Japanese chub mackerel (Iizuka et al., 1983). Further surveys and studies on both species are highly desirable in the immediate future.

Two bilateral fisheries agreements have been established for the management of mackerel stocks in the Yellow Sea and East China Sea. These are the China-Japan and Japan-Korea Rep. Fisheries Agreements, and these impose limitations of fishing intensity through various means, including regulation of season and the imposition of catch quotas. These measures are, however, limited geographically to a part of the West Kyushu and the Western East China Sea stocks.

The major causes of the sudden increase in mackerel stock abundance in the 1960's are not clear. It was reported that a high level of spawning was observed for a few years prior to the outburst of the Pacific stock (Watanabe, 1970). Also good survival of larvae was observed at this time (Watanabe, 1977, 1983). It seems likely that favourable conditions had benefitted recruitment on the spawning stock, and spawning. Watanabe (1983) suggests that favourable environmental conditions, together with an enhancement of reproductive potential associated with changes in density-dependent factors when the stock was low, might have benefitted the stock during the ascending phase. However, the greater spawning followed by good survival in the 1960's still remains a mystery as was the case of the Japanese sardine. This will be discussed further in a later section of this paper. Although the stocks appear to be at a high level even in recent years it will be interesting to see what happens in the immediate future, particularly in connection with the recent outburst in Japanese sardine. Meantime, the conservation of spawning stocks at a certain level may be the most prudent and principal line to follow in any future management plan, as was discussed for sardine stocks.

7.3.6 Japanese Jack mackerel, *Trachurus japonicus* (Temminck et Schlegel)

Japanese Jack mackerel in the area are distributed in almost the same way as Japanese chub mackerel, i.e. in the waters around Japan to the southern East China Sea. The major concentrations however are located further south in warmer waters. These fish also exhibit long term changes in stock abundance.

1/ Includes the catch from the western part of the Japan Sea stock.
2/ Including the catch of spotted chub mackerel.

A purse-seiner belonging to the Shizuura Fisheries Cooperative, Suruga Bay, central Pacific coast, Shizuoka prefecture.

Photograph taken by K. Soehata (Yamaha Motor Co. Ltd., 1984).

A purse-seiner belonging to the Naru-cho Fisheries Cooperative, Goto Islands, East China Sea coast, Nagasaki prefecture.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1984).

PHOTOGRAPH 7. Catch of Japanese chub mackerel by a night-operation of a one boat purse-seiner. The catch includes the incidental bycatch of spotted mackerel, Japanese Jack mackerel and Others. A fleet is usually composed of a seine-boat (20 GRT), two transport/search boats (10-20 GRT), two light boats (15 GRT) and a skiff (2 GRT).

PHOTOGRAPH 8. Sorting the catch from a mixture of Japanese chub mackerel, spotted mackerel, Japanese Jack mackerel and Others on a transportation boat in the base port in the morning after a purse-seine night operation. Sorting is usually carried out by housewives while the fishermen are taking a nap. Vessels shown behind are part of the purse-seine fleet belonging to the Naru-cho Fisheries Cooperative, Goto Islands, East China Sea coast, Nagasaki prefecture. See Photograph 7 for details of the construction of a fleet.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1984).

The structure of the population appears to have changed in association with the change in abundance. For instance, when there was a high stock level during the late 1950's to the late 1960's four major stocks were identified. These were: (1) the Eastern-Central East China Sea stock with a prominent biomass, (2) the North Kyushu stock along the west and north coasts of Kyushu to the western Japan Sea coast of Japan with a second large biomass, (3) the North Japan Sea stock along the northern Japanese coast and (4) the South East China Sea stock. The first two of these stocks were associated at spawning time to form spawning shoals similar to those of the Japanese sardine during the "Great Catch Period." However, the Jack mackerel stocks separated into small local stocks along the Japanese coast when the stock abundance declined after the late 1960's.

The total catch of Japanese Jack mackerel increased suddenly during the late 1950's to reach a level of about 500,000 t (Figure 25, Appendix Table 16). The catches were taken mostly by the Japanese and partly by the Korea Rep. fisheries, and were based on the abundant stocks referred to above. The catch from the Pacific coast which depended on recruitment from the Eastern-Central East China Sea stock and on several small local stocks, did not show a comparable increase during the period.

The reason for the large increases referred to above is not clear. There is no doubt that there was a substantial increase in the fishing efficiency of the Japanese fleet and that an expansion of fishing grounds contributed to greater catches (Mitani et al., 1964, 1965, 1966, Japan, Fisheries Agency, 1973b, 1976). The Japanese fishery was composed mostly of medium-sized one-boat purse-seiners and these found good fishing grounds for Japanese Jack mackerel in the central to eastern East China Sea in 1957 following a rapid expansion of fishing on the Eastern Central East China Sea stock. The purse-seine fishing efficiency has also substantially increased about 1.7 fold during the period 1956-63 (Mitani et al., 1965) and about 1.2-1.3 fold during the period 1963-73 (Japan, Fisheries Agency, 1976). However, there have been few reports published so far[1/] to say whether the stock abundance of Jack mackerel increased before or during the above-mentioned period.

The author assumes that the major stocks had increased in abundance before large catches were taken in the late 1950's for the following reasons: (1) the catch by Korea Rep. started to increase a few years before the expansion of Japanese fishing (Appendix Table 16) when fishing by Korea Rep. was limited to coastal waters and the fishing efficiency was still at a low level (cf. Figures 16 and 23), (2) a substantial increase in the Japanese catch was recorded in coastal waters along the north and west coasts of Kyushu during the period 1951-54 (Mitani, 1966, Japan, Fisheries Agency, 1973b) which was well before the larger catches were taken, (3) a minor stock in the Seto Inland Sea also showed an increase in abundance since the late 1950's and remained at a relatively high level during the 1960's as in the case of the major open sea stocks (Japan, Fisheries Agency, 1976) and (4) the increased catches during the 1960's associates well with the sharp decline in the Japanese sardine stock (Japan, Fisheries Agency, 1973b) which is consistent with the Kawai et al. (1981, 1983) hypothesis, see footnote. It is possible that the Eastern-Central East China Sea stock had only slightly been exploited before 1957 as a by-catch of the Japanese offshore trawlers. However, it is quite likely that the stock together with the neighbouring North Kyushu stock, had been about to increase in abundance prior to the commencement of intensive fishing.

The catches from the two major stocks which had remained at a high level until 1966, dropped sharply in 1967, and have declined continuously thereafter to an extremely low level at present (Figure 25, Appendix Table 16). Japanese scientists consider that the large catches during the early 1960's may have contributed to the decline in stocks during the later half of the 1960's (Japan, Fisheries Agency, 1973b, 1976). Whilst this may be one of the major factors, the author assumes here again that environmental factors as well as fishing might have played an important role in the decline of the stock. The reasons for suggesting this are: (1) there were indications of a decline during the period of the high catches in association with a large oceanographic anomaly which took place in 1963 (Nakai et al., 1967), (2) a decline is observed in all the stocks around Japan including small local stocks which may have not been overexploited (Figure 25 and Japan, Fisheries Agency, 1976), (3) none of these stocks have shown any definite signs of recovery for the past 15 years (Figure 25 and Japan, Fisheries Agency, 1976) in spite of the fact that the fish has a relatively short lifespan, 5-6 years, and matures at age 1.5-2 (Mitani et al., 1964a, Nakashima, 1982, Japan Fisheries Agency, 1973b, 1976)[2/] and that fishing effort has been very low during the later period because fishermen

1/ The only exceptional papers are Kawai et al., 1981 and 1983 which discussed the increase in stock abundance of Jack mackerel; in connection with the change in dominancy among coastal pelagic fish around Japan.

2/ Both ages were about 2 years older at the initial stage of the prosperous period (Japan, Fisheries Agency, 1973b).

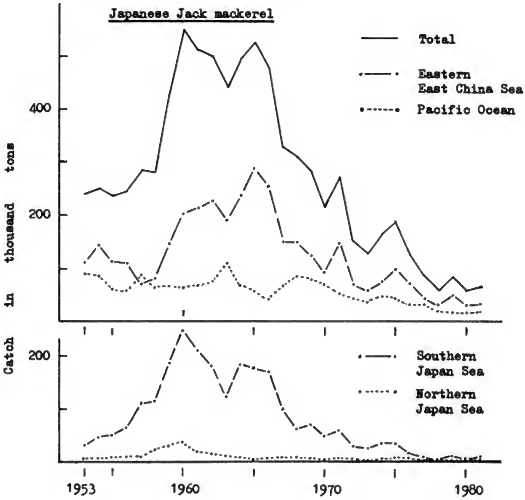

Figure 25. Japanese catch of Japanese Jack mackerel by region during 1953-81. See Appendix Table 16 for statistics.

have shifted their target species to Japanese chub mackerel and, more recently, to Japanese sardine, (4) the sharp decline in abundance of the major two stocks took place at the same time as the rapid increase in the abundance of Japanese chub mackerel (Japan, Fisheries Agency, 1973b, Cho, 1981) and (5) the continuous decline in all the stocks around Japan coincides well with the increase in abundance of Japanese chub mackerel and more recently, of Japanese sardine around Japan. It seems likely that many factors are involved including biological factors, environmental factors, density-dependent factors, inter-specific relationships with other fish species and with carnivorous plankton.

A minor stock in the southern East China Sea has been exploited by the Japanese fishery during 1965-68 yielding about 50,000 t annually. Thereafter the catch decreased (Japan, Fisheries Agency, 1973b, 1976) and has remained at a very low level in recent years. The sequence of events appears to be quite identical to that for the two major stocks. The Chinese catch from this stock is not known. Another minor stock in the northern Japan Sea shows a similar sequence of events though the catch is small and the changes are not large (Figure 25, Appendix Table 16). Several local stocks along the Pacific coast of Japan do not show significant increases throughout the years but do show a continuous decline since the late 1960's consistent with the decline in other stocks (Figure 25, Appendix Table 16). These events suggest that there may have been a common environmental cause underlying the changes in the abundance of each stock.

Two international joint management measures similar to the one for Japanese chub mackerel have been established for part of the two major stocks, by the China - Japan and Japan - Korea Rep. Fisheries Agreements.

Further studies of the processes involved in the changes in stock abundance are needed to provide a basis for rational management. It is interesting to see that many closely related Carangidae species,[1/] do not show such a large long-term change in stock abundance. It may therefore be worth carrying out comparative studies with these species. They are abundantly distributed in the East China Sea and the South China Sea and have probably been exploited heavily by the Chinese fishery (Zhu, 1980).

7.3.7 Japanese amberjack (yellowtail), Seriola quinqueradiata Temminck et Schlegel

The distribution of Japanese yellowtail is similar to that of Japanese Jack mackerel except the northern limit extends further north and includes the waters along the Pacific and Japan Sea coasts of Hokkaido and the east coast of the Korean Peninsula to the Primorskiy coast. This species is characterized by its rapid growth, and large body size attained; about 35 cm, 55 cm, 70 cm, 85 cm and 90 cm at ages 1 to 6 respectively. Maximum size is estimated to be about 95 cm and the lifespan is 7 years. Most fish mature at age 2.5 to 3 and the fecundity is quite large, 0.6 to 1.1 million.

There has been no consensus on the population structure of Japanese yellowtail even though many surveys and studies have been carried out. This is due mostly to the complicated migration pattern and the irregular appearances of the fish in some waters. There is a large spawning ground in the waters along the south and west coast of Japan to the eastern and southeastern East China Sea with 3 or 4 different concentrations in different seasons, February-March and March-April (Japan, Fisheries Agency, 1973c). Eggs and larvae are transported to the Pacific Ocean and to the Japan Sea by the Kuroshio and Tsushima Warm Currents. The fry usually shelter under floating seaweed which is one of the peculiar habits of the fish and the fry are further transferred together with their shelters to the east (Pacific Ocean) or to the north (Japan Sea). The fish are therefore separated into two groups, and these do not meet up until they mature at age 3. Juveniles begin their seasonal migrations after age 1, generally moving to the north in summer and to the south in winter.[2/] Nevertheless, they appear to remain distinct in each of their separate zones. The adult fish, older than age 3, generally move to the spawning ground in the south during the winter to spring and subsequently migrate to the north. This migration is generally repeated, on a seasonal basis, for 3-4 years until the end of their life. The fishing season along the coasts, including the Korean Peninsula (Han et al., 1974), therefore occurs twice a year, in spring and autumn in association with the seasonal migrations. During the wintering and the spawning seasons the Pacific group and the Japan Sea group seem to substantially intermingle, however, the major portion of each group appears to be separate. Hypotheses on a single, two (Japan Sea and Pacific) and more (Japan Sea plus several

1/ Decapterus spp. including round scad, D. maruadsi, brownstriped mackerel scad, D. muroadsi, mackerel scad, D. russellii, Layang scad, D. macrosoma and red scad, D. kurroides.

2/ The movements observed locally are highly complicated especially along the Pacific coast of Japan (Tanaka, 1972, 1972a, 1973, 1975, 1979) but simpler in the Japan Sea (Watanabe, 1978, 1979).

Pacific) stocks have been, in these circumstances, proposed so far. The author deals with the entire yellowtail in the area as a single stock in this paper putting emphasis on the overlap of the reproductive areas.

The total catch taken by the Japanese fishery had been fairly stable until the early 1970's with about 50,000 t (Figure 26 and Appendix Table 17). Different components of the total catch however, show different trends (Figure 27 and Appendix Table 17). For example, yellowtail have been traditionally harvested by large set-nets along the coast and have been one of the most important components of the fishery in terms of both quantity and value. The catch by set-nets has continuously declined since the early 1950's however and recent catches are relatively low at about 10 000 t annually or about 1/3 to 1/4 of catches during the prosperous period. A catch record for selected set-nets along the central Pacific coast of Japan clearly shows a drastic decrease in the availability of the fish to the fishery (Figure 27, Appendix Table 17). A similar sequence of events has been observed along the entire coast of Japan, and probably along the east coast of the Korean Peninsula to the Primorskiy coast too. In contrast, the catches by hook and line and seine nets have gradually increased during the period and are now equivalent to catches by the traditional set-nets (Figure 27, Appendix Table 17). It is noted that medium to large sized purse-seiners began catching yellowtail recently.[1/] It is also noteworthy that catches by small-scale set-nets are now about double to those during the 1950's in contrast to large set-nets although the quantities landed are very small.

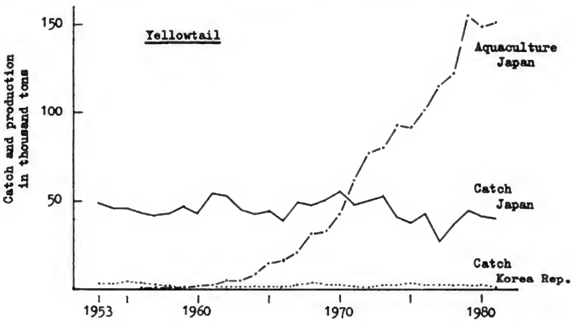

Figure 26. Catch of yellowtail by country and aquaculture production in Japan. See Appendix Table 17 for statistics.

The reasons for the drastic decline in the availability of fish to the large set-net fishery are not clear. Until the early 1970's stock abundance appears to have been fairly stable, (Figure 26) and the sharp decline in the set-net catch first took place before the other gears had significantly increased (Figure 27). Traditionally, the availability of fish to coastal fixed gears was highly variable, due to fluctuations in year-class strength (Mitani, 1959, 1959a, 1957, Mori, 1964, Kawai, 1969, Watanabe, 1968), and also to changes in migration routes in association with changes in environmental conditions[2/] (Tanaka, 1972, 1972a, 1973, 1975, 1979, Kawai, 1969). The record of set-net fisheries along the central Japan Sea coast shows several periods of high catches in the past by a few strong year classes for each rise[3/] (Watanabe, 1968). The sharp decline from the latest peak during the later half of the 1950's accords well with the same phenomenon observed along the Pacific coast (Figure 27).

1/ The annual catches in 1980 and 1981 were 700 and 1,400 t respectively.

2/ It appears, however, that highly complicated movements can sometimes occur without any significant correlation with the environmental change.

3/ Watanabe (1968) estimated that this would result from an extraordinarily large spawning, however, clear evidence for his assumption has not been given. The reasons for these increases, therefore, still remain unclear. Good spawning, good survival at an early life stage, a mixture of these or the involvement of other factors are all possibilities.

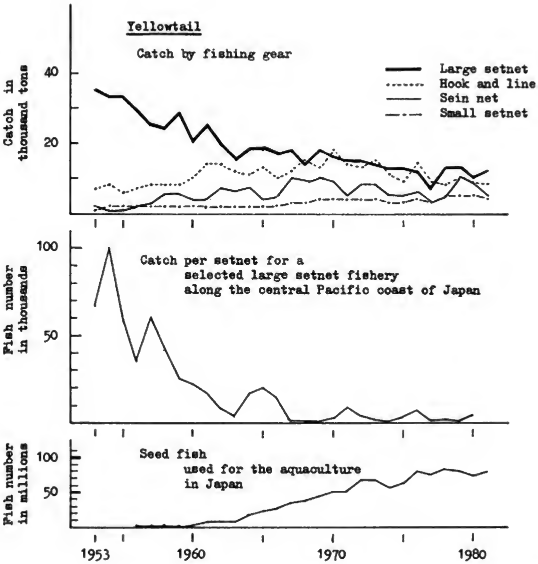

Figure 27. Catch of yellowtail by major fishing gear in Japan and the annual change in the catch per setnet for a selected large setnet fishery along the central Pacific coast of Japan. The number of seedfish used for aquaculture in Japan is also shown for comparison. See Appendix Table 17 for statistics.

It is noteworthy to see that the age composition of the catch by the set-net fishery had rapidly become younger in accordance with the decline in catch. The decrease in the older fish, aged 3 and 4 which had been prominent during the early 1950's, is most serious (Japan, Fisheries Agency, 1973c). It is probable that the offshore fishing by hook and line or seine-net harvest younger fish than by the set-net fishery which possibly results in a decrease in the older fish in the entire stock and eventually in the exploitable fish for the set-net. However, the sharp decline occurred chiefly during the 1950's when the offshore fishing was not heavy (Figure 27). The author assumes therefore that some substantial changes might have occurred in the migratory route of older fish or that the feeding migration from the spawning ground to the northern coasts may have changed probably on a temporary basis. The actual magnitude of spawning appears to have been maintained at a fairly high level (Kurogane, 1972, 1972a, Japan, Fisheries Agency, 1973c, Koto et al., 1982), which indicates the existence of sufficient adult fish in the spawning ground. Another important feature of the fish is its high ecological niche. The fish is a piscivorous species feeding intensively on various types of fish including planktivores, omnivores and squid (Mitani, 1958), and when competitive situations occur the fish takes always an ecologically dominant position with other omnivorous fish such as Japanese chub mackerel (Hatanaka, et al., 1958). The change in dominancy in other neritic pelagic fish may therefore have been rather irrelevant to the change in abundance or the ecological status of yellowtail. However, the burst in other ecologically lower fish probably affected the fishing conditions of set-net as was seen in the catch of filefish (Figure 18) and more recently in the massive catches of Japanese sardine by set-net, though these may be minor and fragmental factors to the large change in availability.

A recent important development in the Japanese fishery is the rapid expansion of yellowtail aquaculture and recent annual production is more than three times the catch of wild fish (Figure 26, Appendix Table 17).

Seedfish[1/] are collected when the fry and juveniles of yellowtail (4-10 cm body length) are drifting under floating seaweeds by small seine-nets and scoop-nets mostly along the west coast of Kyushu and the southwestern Pacific coast of Japan (Mitani, 1965, 1968, Kurogane, 1972, 1972a, Asami et al., 1967, Koto et al., 1982). The rapid expansion of aquaculture was due partly to developments in ways of catching seed fish and culturing them in cages or marine enclosures, partly to commercial success and partly to the abundant supply of feed material in raw or fishmeal of Pacific sandlance, chub mackerel and more recently of Japanese sardine. The number of seed fish employed has continuously increased and the level has recently reached about 75-80 million fish which is enormously greater than the catch of wild fish (Figure 27, Appendix Table 17). The abundance of "Mojako" is thought to have remained at a high level until the early 1970's even though the catch of seed fish had already exceeded 50 million fish (Kurogane, 1972, 1972a, Japan Fisheries Agency, 1973c, Koto et al., 1982). Reproduction therefore seems to continue at a high level in spite of the massive reductions in juveniles. It has been said that this huge reduction in juvenile fish would lead to overexploitation, however, there has been almost no sign so far on any decline in abundance of "Mojako" and this may indicate that the spawning potential of the stock is still at a high level in spite of the disappearance of the older adult fish from the northern coast.

The catch by the Korea Rep. fishery along the east coast of the Korean Peninsula has been relatively very small throughout the years (Figure 26, Appendix Table 17). However, the changes in availability and the abundance of fish exploitable to the Korean fishery are probably the same in nature to the fish around Japan as the fish is a part of the same stock (Japan, Fisheries Agency, 1973c, Han et al., 1974).

It is very interesting and important, in this connection, to see that the estimated larval loss of predation by other fish and cannibalism during the "Mojako" stage is surprisingly large (Asami et al., 1967, Koto et al., 1982). The loss from cannibalism during a period of one month would be substantially large, 0.95 in the worst case and 0.67 at best. The loss may reach 0.25-0.50 even if the period is limited to only eight days, which is fishing days of a "Mojako" school under floating seaweed. This is nearly equivalent to the catch rate of the "Mojako" by the fishery, 0.3-0.8. It is quite likely that such a drastic and complicated mechanism is involved in the population dynamics of Japanese yellowtail as was proposed generally by Kawai et al., (1983). Further intensive surveys and studies on the entire lifespan are required in the future.

1/ "Mojako" in Japanese means "tiny fish gathered together under seaweeds".

7.3.8 Japanese Spanish mackerel, Scomberomorus niphonius (Cuvier)

Japanese Spanish mackerel are widely distributed in the waters along the southern and southwestern coasts of Japan to the Yellow Sea including the Po-Hai Sea and some parts of the East China Sea. Not much is known about their life history since the major fisheries on this species have only recently been developed, especially in China and Korea Rep. (Figure 28, Appendix Table 18). In Japan, on the other hand, although this nation has traditionally utilized fish, investigations of this species have been hampered firstly by the limitation of commercial fishing. The very high commercial value and tendency for catches to spoil have also interfered with the biological sampling of the commercial catches in Japan.

As a result, there are no overall reviews of stocks in the area. One group of fish in the northern and western Yellow Sea may form a large single stock as the Chinese catch appears to have been taken continuously from these coasts (Wang, 1982). It is reported, however, that the fish migrate to the East China Sea during the winter (Ibid.). It appears that there is a smaller stock in the Seto Inland Sea of Japan since spawning has been observed in the sea every year and the wintering grounds of the fish have been confirmed in the neighbouring southern waters (Hamada et al., 1967). Another small local stock may be located around the Tsushima Strait to the eastern part of the Yellow Sea along the Korean Peninsula since a substantial amount of fish have been caught there almost all the year round as well as during the spawning season (Whang, et al., 1977). There may be other stocks along the southern Pacific coast of Japan. Overall about four stocks probably exist in the area.

The fish appear to have some ecological features in common with those of Japanese yellowtail. For example: (1) they occupy a high trophic level since they feed intensively on other pelagic fish of species (Yokota et al., 1961), (2) they undergo distinct seasonal spawning migrations[1/] and form massive spawning concentrations in April to June,[2/] (3) they show rapid growth and attain large body size (Hamada et al., 1967, Liu, 1981) and (4) they mature early at age 2 (Ibid.). It is surprising to see the fact that the fish grow about 33-46 cm within 6 months after hatching but the growth rate becomes flattened afterwards (Hamada et al., 1967), and the body lengths at ages 1-4 are 42, 55, 62 and 67 cms respectively (Liu, 1981). The lifespan appears to be 6-7 years with a body length of 85-90 cm.

The Chinese fishery had developed rapidly during the 1960's and the catch in recent years has exceeded that of other nations with about 50,000 t annually (Figure 28, Appendix Table 18). This catch has been taken mainly by surface gillnet and mostly from waters along the northern coast of China (Wang, 1982), where the Yellow Sea stock contributes a large biomass. The fishing seasons are formed twice a year in connection with the spawning and wintering migrations of fish (Wang, 1982). These are in spring when about 60 percent of the catch is taken and in autumn when about 40 percent is taken.

The remarkable increase in the Chinese catch was chiefly due to a great increase in fishing effort, since the number of gillnets employed has increased more than three-fold during the past 15 years. The catch-per-unit-effort (cpue) has shown signs of a decline in recent years, possibly as a result of the intensification of fishing. It was estimated that the stock had already been fully or slightly overexploited by the late 1970's (Zhu, 1980, Wang, 1982). However, the precise status of the stock is still not clear. Firstly, the decline in cpue is to some extent a general feature in a developing fishery[3/] and secondly the age composition of the catch and the number of the spawners had remained almost unchanged by the end of the 1970's (Liu, 1981, Wang, 1982).

Taken as a whole, there seems to be almost no sign of overexploitation observed on the abundance of the Yellow Sea stock. However, it may be true that exploitation has been approaching its maximum level. Prudent management measures should therefore be implemented in the immediate future as was proposed by Zhu (1980) and Wang (1982). Further surveys and studies should be carried out. It is believed that Korea D.P. Rep. also utilize the Yellow Sea stock of Japanese Spanish mackerel, but there is no information on the catch.

1/ In contrast to Japanese yellowtail, offshore spawning in yellowtail versus nearshore spawning in Spanish mackerel.

2/ Some spawning a few months later (June to August) was observed for the Tsushima Strait stock in 1973 (Whang et al., 1977), however, it is not clear whether this is a characteristic of the stock or a temporary delay in spawning in that year.

3/ In fact bad cpue's are observed even in the earlier stages of the fishery and good cpue's are observed even in the late 1970's.

The catch by Korea Rep. has also steadily increased by a factor of two during the 1970's (Figure 28, Appendix Table 18). The catch has been taken mostly from the waters along the southern and southwestern coasts of the Korean Peninsula (Whang et al., 1977), where the Tsushima Strait stock may have been dominated with a smaller biomass than the Yellow Sea stock. Most of the catch appears to be composed of adult fish, age 2 and 3 (Whang et al., 1977). Two distinct features of the Korean Rep. catch are: (1) the majority of the catch is taken by large-size purse-seiners in offshore waters, 50-67 percent of the total catch and (2) the fish are caught all the year round, with peaks in catches in spring, from February to April and in autumn, from October to November.1/ The first of the above may possibly be one of the reasons for the second, i.e., the offshore fishing could locate the fish which have moved away from the coast after spawning.

However, there are other considerations to take into account. For example: the waters along the south coast of the Peninsula, where the Tsushima Warm Current prevails throughout the seasons, may be favourable even in winter for fish including those migrating to the east coast of the Peninsula and the western Japan Sea coast of Japan. The stock therefore if it is really a single unit, would not need to leave its main habitat even in winter due to the favourable winter conditions provided by the Tsushima Warm Current.2/ If this is true, the spawning and migratory patterns of this stock and also the nature of the fishery should differ greatly from those in other stocks in the area. Reported spawning in summer (Whang et al., 1977) could be associated with this. Future investigations of the life history of these fish are strongly desirable.

The state of exploitation of the stock is not clear, but is probably similar to that of the Yellow Sea stock approaching maximum level.

Although in recent years the catch is the smallest among the nations concerned, the Japanese catch of Spanish mackerel goes back to the 17th Century (Figure 28, Appendix Table 18). The most intensive fishing has been traditionally carried out in the Seto Inland Sea where about 50 percent of the total Japanese catch has been taken in recent years. These fish, together with red seabream, have constituted an important fishery product in terms of commercial value, and this was especially so in ancient times.3/ The principal fishing methods employed (surface gillnet and trolling) and the fishing seasons (spring and autumn) have remained unchanged throughout the history of the fishery though there have been big developments in gear and vessel technology in recent years.

The catch from the Seto Inland Sea which has exclusively depended on the Seto Inland Sea stock has about tripled during the past 15 years from about 1,000 to 3,000 t.4/ This increase appears to have been chiefly due to an increase in the abundance or availability of the fish rather than to an increase in fishing intensity. Management measures in coastal waters in Japan have been strictly enforced to prevent an uncontrolled increase in fishing intensity (Asada et al., 1983). There are two fishing seasons each year, one during April to June and the other during September to November catching spawning fish in the former season and feeding fish in the latter. Spawning takes place in a fairly short period, from early to mid-May in the inner part of the sea. This is one of the distinctive characteristics of the stock, and the fish winter in adjacent southern waters (Hamada et al., 1967). Spawning fish have consistently been composed of 2 year old fish (Ibid.). Although an explicit assessment has not been attempted the stock appears to have been fairly stable at a favourable level in recent years.

The Japanese catch along the central to southern Pacific coast of Japan has also been fairly stable throughout the years. A proper assessment is not possible for these fish due to lack of information. However, it appears that the state of the stocks may be identical to that of the Seto Inland Sea stock as the fishing has never been intensively attempted.

1/ Source: Korean Yearbooks of Fisheries Statistics.

2/ In fact, the major fishing ground is formed only in the south of the Peninsula during December to April while it extends to the Yellow Sea side of the Peninsula during the other seasons (Whang et al., 1977)

3/ For this reason, exclusive fishing had been performed for catching these fish in the sea by a few selected fishing communities during the feudal era under special rights granted by the central or local lord. A picture of a small fishing village illustrated on the cover page of FAO.Fish.Tech.Pap., (238), Fishery Management in Japan (Asada et al., 1983) shows a sketch of such a fishing community in present day.

4/ Source: Japanese Yearbook on Fisheries Statistics.

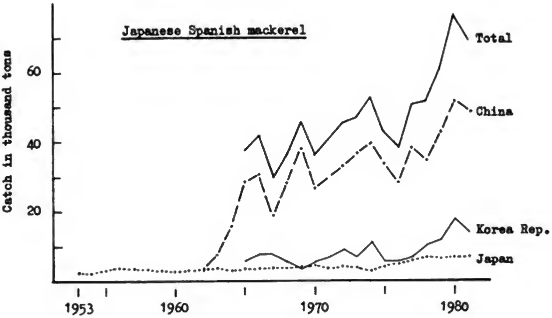

Figure 28. Catch of Japanese Spanish mackerel by country. See Appendix Table 18 for statistics.

Biological information for an important part of the life history is still lacking for all the stocks. For example, data on reproductive potential, details of the early life stage, feeding habits and inter-specific relationships are almost entirely lacking. It may be difficult to gather this information but future investigations are strongly recommended. Information on larvae and fry is especialy important considering the probable loss by predation and cannibalism as in the case of Japanese yellowtail.

Studies are also needed to determine the relationships with other Spanish mackerel species occurring in the area especially in southern waters. It has been reported that several Scomberomorus spp.[1/] are widely and abundantly distributed in warm to tropical waters in the Indo-Pacific region (Fischer et al., 1974, Kyushin et al., 1982, Collect et al., 1983). It is believed that these fish have been commonly harvested along the southern coast of China, including Taiwan Province.[2/]

However, neither biological information nor catch data are available so far. Species identification of the catch should firstly be established through scientific surveys as these fish are generally difficult for fishermen to distinguish. Later arrangements should be made to collect both biological and catch data. Studies of these fish should undoubtedly aid the overall understanding of Scomberomorus spp. including Japanese Spanish mackerel.

7.3.9 Summary for coastal pelagic fish

The total catch of coastal pelagic fish from the area has about doubled from about 3.2 to 6.2 million tons during the past 10 years. However, the species composition of the catch has greatly changed. In particular there has been a big decrease in Pacific herring and Japanese Jack mackerel catches and an extraordinarily rapid increase in Japanese sardine (Figure 3, Table 9). Changes in catch composition like this have been frequently displayed by each of the coastal pelagic fish[3/] in the area if the historical record is examined.

1/ These include: narrow-barred Spanish mackerel, S. commerson, Indo-Pacific King mackerel (Taiwanese Spanish mackerel), S. guttatus, Korean seerfish, S. koreanus, and Chinese seerfish, S. sinensis.

2/ In fact, Liu (1981) found a great difference in the morphometric characters between the Japanese Spanish mackerel caught in the Yellow Sea and the reported fish caught in the Formosa Strait (Chen, 1974), which suggests different species occurring abundantly in southern waters.

3/ Japanese yellowtail and Japanese Spanish mackerel appear to have followed somewhat different courses due to their different ecological status as was discussed in each section.

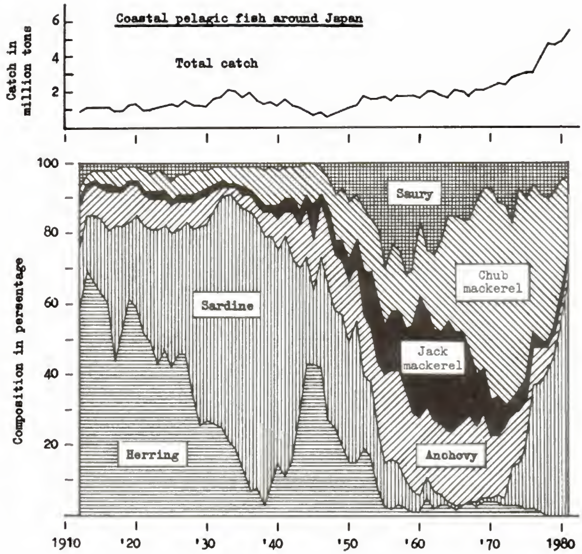

Figure 29. Long-term change in the total catch and species composition of the major coastal pelagic fish around Japan. See Appendix Table 19 for statistics.

An important suggestion in this paper is that natural conditions may have had an important effect on the long-term fluctuations in stock abundance. Fishing mortality on the other hand, may have played a smaller part in causing changes in stock abundance. For instance, some stocks increased when fishing was heavy (e.g., Japanese sardine and Japanese chub mackerel) while other stocks declined continuously regardless of substantial reductions in fishing effort (e.g., Pacific herring and Japanese Jack mackerel). The Japanese anchovy did not show a drastic change in stock abundance in spite of heavy fishing and tremendously large predatory losses throughout their lifespan. It is considered that the tolerant nature of the anchovy stock may have saved it from serious deterioration and that the large predatory loss, which has also been realized under the tolerant nature of the stock, may have controlled the burst on the other; in other words, these two functions may have been well balanced to keep the stock abundance at a certain level. What then are the factors involved which have enabled the stocks to maintain stable populations? The author reviews these phenomena here again, in conjunction with the changes in dominancy in the pelagic fish community in waters around Japan.

The historical catch record of the major pelagic fish species around Japan is given in Appendix Table 19 and their percentage composition is given in Figure 29 together with the catch for all species combined. The catches taken mostly by Japan and partly by the Korea Rep. and the USSR, have accounted for about 70-90 percent of the total pelagic fish catch from the entire area. Figure 29 shows how species composition has changed over the period from 1910-1980. The entire period can conveniently be split into two different periods, one before and one after World War II, i.e. a simpler structure of species and monotonous change in dominancy in the former period and varigated for those in the latter. During the 1910's-20's the dominancy gradually changed from herring to sardine which coincides with the beginning of the "Great Catch Period" of sardine during the 1930's, after which herring again became dominant in the mid-1940's in connection with a temporary recovery of herring stock. The coastal waters around Japan during the period are therefore considered to have been dominated by these two species, sometimes by either of them and other times (transitional period) by both (Figure 29). It is not certain to what extent the other species had really been stable at a low level as shown in the nominal catches throughout the period - more than 30 years. It may be reasonable to consider that the change in abundance might have occurred to some extent even in other species in further offshore waters which were a difficult access to fisheries at that time with lower fishing efficiency.[1/] Even if these assumptions are taken into account, there is no doubt that herring and sardine dominated during the Pre-War period. However, their dominancy was lost firstly from herring and secondly from sardine when the community changed to the second phase during the 1940's.

Since the mid-1940's the species composition of the pelagic fish community has become highly diverse (Figure 29). For example, after the sharp decline in the herring and sardine stocks, saury and Jack mackerel became dominant and anchovy also became more important during the 1950's (Figure 29). Strictly speaking, saury became dominant in the waters along the northern Pacific coast of Japan[2/] while Jack mackerel became dominant in the waters along the southern and western coast of Japan including the Japan Sea coast. From these, the annual catches consisted of 60-70 percent (saury) and 40-60 percent (Jack mackerel) out of the total pelagic fish catch in these regions. The increase in anchovy stock on the other hand was observed uniformly along the entire coast of Japan.

Saury began to decrease around the early 1960's and Jack mackerel a few years later (Figures 21, 25 and 29). In association with these declines, chub mackerel began to increase during the 1960's and by the beginning of the 1970's this fish had markedly increased over the entire coast of Japan and was taking a prominent position in the community (Figures 24 and 29). The catch of chub mackerel accounted for 40-60 percent of the total pelagic fish catch for about 10 years until the mid-1970's. The abundance of Jack mackerel has declined continuously while saury have remained at a modest level during the period (Figures 21, 25 and 29). It is interesting to note that the total pelagic fish catch has stayed at nearly the same level of about 1.7-2.2 million tons, for about 20 years during the 1950's-60's in spite of the changing species composition of the community.

1/ For instance, the catch of saury had markedly increased in accordance with the development of stick-held dipnet fishing in offshore waters since 1949 (Japan, Fisheries Agency, 1973a) and that of Jack mackerel with the development of one-boat purse-seining since the mid-1950's (Japan, Fisheries Agency, 1973b).

2/ Probably also dominated in southern and southwestern waters where major spawning of the stock took place during January to April, though the fish had not been caught commercially as fishing had been prohibited during January to June every year to preserve the spawning stock.

Although chub mackerel was dominant during the first half of the latest decade, sardine has again taken over as the dominant species since the mid-1970's (Figure 29). However, the abundance of chub mackerel is still at a relatively high level (Figure 24) and the very large catch of sardine, following the rapid increase of the stock since the early 1970's (Figure 22), has led to a remarkable increase in the total catch of all species during the past decade (Figure 29). The anchovy stock seems to have been declining in association with the recent outburst of sardine. However, this declining trend is fairly gradual and appears to have levelled off in recent years (Figures 22, 23 and 29).

It has now become apparent that changes in stock abundance in each of the major pelagic resources around Japan have not taken place independently but have been associated with complementary changes in other stocks. Dominancy, as a result, has switched from one species to another. However, studies of these phenomena are rather limited; for example saury to chub mackerel (Mitani, 1970, Kawasaki, 1971a), sardine to Jack mackerel (Mitani, 1970), the role of predatory loss in general (Kawai et al., 1981, 1983) and a theoretical consideration of the process (Shirakihara et al., 1978, Tanaka, 1983, 1983a). A consistent assumption throughout these studies is that a substantial decrease in the abundance of a dominant species for some reasons[1/] may have given one of the competitive species an opportunity to use surplus feed organism and vacant space to increase its abundance. Considerations of this kind are likely but do not explain all interspecific changes. For example, chub mackerel continued to be abundant all over the region at the time of the recent outburst of sardine.

The possibility of species interaction (Shirakihara et al., 1978) and its application to the sardine and chub mackerel stocks (Tanaka, 1983a) appears, in this regard, to be quite reasonable. That is, once the sardine stock has grown to a certain level it may be able to compete with mackerel even though mackerel is normally the dominant species and feeds on sardine. Once the sardine is able to expand in this way it may eventually be able to take over the dominancy from the mackerel stock. The process or cause-and-effect involved in the interchange of dominancy between any of the two species is probably variable depending on what initiates the process and which species suffers first from this. There may also be simultaneous changes in two species.

What then could be the process that initiates these changes? There have been many possibilites both physical and biological as have been described in the antecedent sub-sections. However, none of them are able to provide an entirely consistent explanation of all of the phenomena observed. There is no doubt that a change in abundance of any stock, is due to highly complicted physical and biological factors, including both the density-dependent and independent processes. It is important therefore to further investigate these phenomena for each species from a global point of view.

In this regard, a working hypothesis proposed by Kawai et al., (1983)[2/] and a theoretical consideration of the non-linear interactions between species made by Shirakihara et al., (1978) are noteworthy. The author believes that the dynamic changes in the pelagic fish community are such that the traditional approaches employed for demersal fish stock analysis involving surplus yield or stock/recruitment models may not be applicable. It is also believed that an analysis of the physical environment and its influence on the pelagic fish community, should be linked with the above-mentioned approaches. In any case these must be long-term objectives and a clear-cut assessment is difficult to make at present as discussed at the FAO Technical Consultation in San José, Costa Rica 18-29 April 1983 (Csirke et al., 1984). Further surveys and studies along the lines laid down at the Consultation are highly desirable in the future.

The management strategy to be followed for these particular stocks must be to conserve the spawning stock to ensure that the reproductive potential is maintained at a satisfactory level, especially during a period of declining stock size. This should minimise the rate of decline, on the one hand, and help the eventual recovery, on the other. Even if appropriate measures are implemented there may be a risk that stocks will still decline as was the case with herring and Jack

1/ Overfishing (Mitani, 1970), oceanographic conditions (Kawasaki, 1971a) and predation on eggs and larvae by carnivorous plankton (Kawai et al., 1981, 1983).

2/ This hypothesis deals only with the declining phase; assuming large predatory loss of eggs and larvae of the dominant species as the initiating factors. The author assumes that there could probably be a reverse process comparable to this, namely, good survival of eggs and larvae due to a decline in the predatory plankton for some reason, which could result in the appearance of a strong year-class from a very low level of spawning such as that of Japanese sardine in 1972.

mackerel. Alternatively, there may be an unexpected increase from a low level of stock size as was experienced with chub mackerel and sardine. It is interesting that total production has remained at a fairly stable level in spite of the changes in species composition during the period from the 1950's to mid-1970's. This could mean that the total production of all species combined is determined by the productivity of the region as was discussed in Section 4 of this paper. In other words, the total pelagic fish production may remain at a certain level even if the species composition is greatly changed, especially with the right kind of management. The long and medium term predictions of changes in fishing and the availability of fish are the most effective management tools for achieving this.[1/] This kind of management may contribute especially to the socio-economic stability of the fisheries.

The degree of expansion of stock biomass during an increased stage appears to be different for different species. It is probably largest for sardine followed by herring and chub mackerel. It is unlikely that the two most competitive and dominant stocks such as sardine and chub mackerel could both experience a large biomass simultaneously due to the limitation of total productivity and habitat as discussed above. Total production in the region in recent years was about 5.5 million tons and this appears to be about the maximum that can be expected. The total catch of the major pelagic fish species from the region is likely to be more variable with a range of 2.5-5.0 million tons depending on which species combination happens to be favoured and how the fisheries choose to exploit them.

With the exception of some pelagic stocks in the East China Sea and northwestern South China Sea, almost all the important coastal pelagic fish resources in the area appear to have been fully exploited.[2/] In recent years the total pelagic fish catch from the entire area has been 5.5-6.2 million tons (Table 9), and this is likely to represent its maximum level. The catch may further increase in the future if there are outbursts of stocks with a potential for a tremendously large expansion such as sardine, but these high catch levels are not likely to be sustainable. The total potential yield of coastal pelagic fish from the entire area is estimated to be 5.8 to 6.5 million tons assuming the same conditions as those adopted for the pelagic fish communities around Japan.

7.4 Tunas and Billfishes

Tunas and billfishes are highly migratory fish and are distributed widely in oceanic waters from the tropics to temperate zones in both hemispheres in the Pacific Ocean. All the fish occurring in the Northwest Pacific are no more than part of large stocks where distributions extend beyond the eastern and southern border of the Northwest Pacific as defined in this paper. The catches of tunas and billfishes from the Northwest Pacific in recent years (Table 10) usually account for less than 50 percent of the total catches from the entire Pacific Ocean.[3/] Furthermore, the major spawning ground of each species is located outside the area, except for northern bluefin tuna which will be discussed to some extent in a later sub-section. A proper assessment for these species would need to take account of the entire distribution range of each species, and this extends beyond the scope of this paper, and will be dealt with separately in another paper. Consequently, only a brief review of each species and fishery is made in this paper.

1/ A highly well organized fisheries forecasting system has been functioning in Japan since around the mid-1960's, which will be documented in another FAO Technical Paper.

2/ It is noted that a medium-sized pelagic fish, Pacific pomfret, *Brama japonica* Hilgendorf is known to be distributed widely and abundantly in the northern North Pacific (Machidori, 1971, Shimazaki, 1979, Sasaki, 1981) and exploratory fishing has been attempted by Japan (Nakamura, 1982). This may be an underexploited fish resource from which substantial catches might be obtainable in the future.

3/ The catch of skipjack had accounted for about 60-70 percent of the total until around the mid-1960's. This was before the large expansion of the fisheries in Japan and the U.S.A. to the Western-Central Pacific area and the intensification of skipjack fishing by the coastal countries there, but is now about 18-28 percent. The catches of larger tuna from the area account for 82-86 percent for northern bluefin, 44-55 percent for albacore, 9-12 percent for yellowfin and 11-12 percent for big eye tunas out of the total catches of each species from the entire Pacific Ocean. The catches of billfish from the area generally accounts for about 50 percent of the total catch from the entire Pacific Ocean with the exception of black marlin which accounts for about 90 percent.

Table 10

Catch of tunas and billfishes during 1970-81.

('000 t)

Species	1970	1975	1976	1977	1978	1979	1980	1981
Skipjack tuna[1/]	166	135	151	129	157	163	174	141
Larger tunas								
Northern bluefin tuna[1/]	15	7	5	8	14	17	14	25
Albacore[1/]	38	48	91	42	70	58	59	49
Yellowfin tuna[2/]	28	36	43	40	36	47	42	48
Bigeye tuna[1/]	13	14	19	18	13	13	12	15
(Sub-total)	(94)	(105)	(158)	(108)	(133)	(135)	(127)	(137)
Smaller tunas[3/]	27	16	22	15	17	18	24	19
Billfishes[4/]	28	30	25	30	30	26	28	30
Total	315	286	356	282	337	342	353	327

1/ Taken mostly by Japan (80-99 percent) and partly by Taiwan, Province of China.
2/ Taiwanese catch accounts for about 50-65 percent of the total catch.
3/ Includes only frigate and bullet tunas, no information is available for kawakawa.
4/ Includes swordfish, striped marlin, Indo-Pacific blue marlin, black marlin and sailfish, no information is available for shortbill spearfish.

7.4.1 Skipjack tuna, Katsuwonus pelamis (Linnaeus)

No consensus has been reached by scientists concerning the population structure of skipjack tuna in the Pacific Ocean although many surveys and studies have been carried out so far. Various hypotheses have been proposed. For example a single stock with a huge spawning ground in tropical to sub-tropic waters extending to both hemispheres (Rothschild, 1965, Kawasaki, 1964, 1965, 1976), two stocks, one in the western Pacific and the other in the central-eastern Pacific respectively (Fujino, 1970, 1970a, 1972, 1976, 1980) and multiple local groups (stocks) linked with neighbouring groups[1/] (South Pacific Commission, 1981, Kearney, 1982, Argue et al., 1982). The difficulty arises due to the ecological complexity of the fish, i.e., a vast spawning ground, a prolonged spawning season lasting nearly all the year round, an unknown early life history from the larval stage to the stage of recruitment to the exploitable stock, a large variation in growth rate, a long-range and complicated migration, and finally the existence of non-migratory local groups as well as groups of large adult fish in deeper water which have been caught by tuna longliners etc.

Fish taken from the Northwest Pacific appear to originate from fish spawned further south beyond the southern border of the area. The fish have been intensively harvested by the Japanese fishery in the area when they migrate to the north for feeding during spring to autumn. The major fishing grounds therefore shift seasonally from the south in spring (the eastern East China Sea) to the north during summer to autumn (waters along the Pacific coast of Japan extending further offshore to oceanic waters along the Kuroshio Extension). Fishing in winter, when the majority of the fish have moved out of the area, is therefore very sparse depending mainly on several local stocks which remain in the area all the year round. Such local stocks have been identified in waters along the Izu-Bonin (Ogasawara) Islands and the Rykyu/Nansei-shoto archipelago. Substantial fishing has been carried out by the Taiwanese fishery in the latter waters exploiting both highly migratory and local stocks.

1/ The hypothesis is called an "Isolation-by-Distance Model" with a continuous (or stepped) cline or "Clinal Population Structure Model". It is assumed that the probability of breeding between groups is inversely proportional to the geographical distance between them.

The total catch of skipjack tuna in the area has not varied significantly during the past decade with an annual catch of 140-170,000 t (Table 10). This has mostly been taken by the Japanese fishery (97-99 percent) and partly by the Taiwanese fishery (1 to 3 percent). The catch in 1981 showed a large decrease, however, this was caused mainly by inactive fishing in Japan (about a 40 percent decline in the Japanese catch from the previous year) due to the economic crisis of the fishery. The Japanese fishery, including the tuna longline fishery has been encountering serious economic difficulties since 1973 with higher fuel and increasing labour costs. In addition the stagnation in the foreign market for canned tuna in recent years has made the situation even worse by reducing the market prices in Japan. In general, there has been a loss of profitability in the industry and the situation is worst in the pole-and-line skipjack fishery. A substantial number of licences have been abolished for fishing boats during 1981-82 owing to these circumstances and the situation is not expected to improve for some years to come. The Japanese skipjack fishery both in coastal and long-range fleets, appears to be gradually becoming reorganized as fishing becomes more profitable with one boat purse-seine.[1/]

The Japanese fishery now appears to have extended to all the exploitable fishing grounds in the area in recent years. It extends from the major fishing grounds along the eastern East China Sea and the Pacific coast of Japan to further east; along the Kuroshio Extension and the North Pacific Current and along the Izu-Bonin (Ogasawara) Islands. This has been made possible, by the provision of an abundant supply of anchovy[2/] for the pole-and-line fishery. Also, there have been recent improvements in the rearing techniques for live bait on board. The Japanese single boat purse-seiners have also expanded their fishing grounds as mentioned above. The skipjack stock(s) in the area seem therefore, to be fully exploited, and a further increase in catch is not likely in the future.

There has been no sign so far of a decline in stock abundance. However, assessments are needed to analyse data collected from the entire distribution range of the fish. A few interesting facts, in connection with this, have been revealed through long-term observations carried out by the Japanese institutes. First, the fish that migrated into the southern Japanese waters, Ryukyu/Nansei-shoto archipelago, in spring every year are composed mostly of a single year-class fish, aged 2 years, with fairly narrow body size range of 40-45 cm (Kawasaki, 1964, 1965, 1976, Kasahara, 1977). This implies that these fish may have been spawned during a fairly short period, probably some time in spring. The results of larval surveys suggest that a peak of spawning may take place during May and June in tropical to sub-tropical waters in the western part of the northern hemisphere,[3/] while there is another peak during November and December in the waters further to the south (Ueyanagi, 1969, Nishikawa et al., 1978). It seems likely that the fish that originate from the spawning in May-June constitute the major part of the catch from the area as there is no doubt that the fish first appear in the south and then move to the north along the Pacific coast of Japan (Kawasaki, 1964, 1965). The results of tagging experiments (Kasahara et al., 1971, Kawasaki, 1976, Kasahara, 1977) and maturity studies (Asano et al., 1971) support these assumptions. Nevertheless, it is unlikely that this migratory route is the only passage for recruits to the northern-most fishing ground. This ground is in the Tohoku region along the northern coast of Honshu, where the largest catch has been taken during summer to autumn each year with an annual catch of 40-60,000 t. There may be other migration route(s) from the nursery grounds in the south to the fishing grounds in the north, possibly moving directly to the north without passing through the eastern East China Sea as was proposed by Kawasaki (1976) and Kasahara (1977). In this connection, abundance in the eastern East China Sea falls sharply in early summer which is consistent with a cessation of recruitment by that route at that time.

Relevant information also comes from an analysis of stomach contents (Mori, 1972). This suggests that they expand their habitat abruptly when the fish attain about 30 cm body length, at age 1, to higher latitudes. Before that, the fish remain mostly in their spawning and nursery grounds where the water temperature is greater than 24^{0} throughout the season (Ueyanagi, 1969). However, details of the habitat and behaviour of the fish until they are recruited to the exploitable stock at age 2, are still uncertain.

1/ The transformation of the fishery, however, would need a long time as the Japanese licensing system is very strict in changing fishing methods in major fisheries and to prevent any drastic confusion and conflict which may arise in the fishing industries if the structure of the fisheries is easily or radically changed (Asada, 1973, Asada et al., 1983).

2/ The abundance of Japanese anchovy around Japan shows a declining trend in recent years as was discussed in a previous sub-section, however, shortage of bait-fish supply may not occur in Japan even if the anchovy stock further declines as sardine have burst around Japan and was mainly used as live bait when available in abundance.

3/ Waters between the Philippines and Mariana-Japan archipelago.

Investigations of the stomach contents of predators have provided useful information about tuna and especially about the earlier life stages, from fry to juvenile, as there are otherwise no effective methods of investigation. It is well known for example that skipjack occupy a high trophic level, and feed intensively on other fish species and especially on coastal pelagic fish as was discussed in the previous sections of this paper.[1/] At the same time, skipjack appear to have been one of the important food items for the larger piscivorous fish species, including tunas and billfishes (Suda, 1953, Watanabe, 1958, 1960, Mori, 1972, 1972a, Nishikawa, 1975). Although the average number of skipjack individuals eaten by one predator varies greatly with predatory species, area and season, and ranges from 0.006-1.347 per stomach, it is noteworthy that relatively much higher values (0.200) is shown for yellowfin tuna which overlap in distribution. Very high values have been observed for sailfish (1.347 in about 900 specimens) and blue marlin (1.024 in about 2,700 specimens), both collected from the Indo-Pacific region (Mori, 1972). The body size of the majority of skipjack eaten by tunas is estimated to be about 6-20 cm, and the upper limit of the size eaten appeared to be about 30-40 cm which is consistent with the rapid expansion of the habitat of skipjack mentioned above. Billfishes generally eat larger skipjack than tunas as they eat 30-50 cm specimens although they also intensively feed on 6-20 cm specimens (Ibid.) The natural mortality of juvenile skipjack due to predation is therefore quite large, and should be taken into account in future studies.[2/]

Special attention should also be given to the relatively large mortality due to predation and cannibalism during the very early life stage. There is no doubt that there is substantial predation on the larvae and post-larvae of skipjack by the juveniles of other Scombrid fish species and especially by yellowfin tuna. For example, large numbers of skipjack, of 15-32 mm have frequently been found in the stomachs of yellowfin tuna (Nishikawa, 1975). Studies of cannibalism among skipjack themselves have scarcely been carried out so far. Kawai (1978, 1978a) and Kawai *et al.*, (1979, 1983) estimated, through a comparative analysis of the feeding habits of fish around Japan in association with their morphology, growth, reproductive potential, ecology and behaviour, that the loss by cannibalism might be quite large in piscivorous fish. Clear evidence of this view, through direct observation, has not yet been obtained, but it appears quite plausible in relation to the biological background of the species. Also, there is some circumstantial evidence. For instance, Nishikawa (1975) has reported that fish larvae in the stomachs of skipjack juveniles of 17-26 mm body length made up about 73.3 percent of the food items by numbers. He estimated that there would be a large consumption of fish larvae in association with the development in the digestive tract of these fish. Although the species of fish larvae were not identified, they could easily have been tuna larvae, including skipjack, since these are distributed abundantly in the area in question. Further studies, including studies of the larval stage, are highly desirable in the future.

7.4.2 Larger tunas, *Thunnus* spp.

Four species of larger tunas have been commercially exploited in the Northwest Pacific. These are: (1) the northern bluefin tuna, *Thunnus thynnus* (Linnaeus), (2) the albacore, *Thunnus alalunga* (Bonnaterre), (3) the yellowfin tuna, *Thunnus albacares* (Bonnaterre) and (4) the bigeye tuna, *Thunnus obesus* (Lowe), all of which are distributed widely in the Pacific Ocean including the southern hemisphere. It seems likely that a smaller species of the same genus, the longtail tuna, *Thunnus tonggol* (Bleeker), is probably distributed with a substantial biomass in the southern part of the area along the Chinese to Vietnamese coasts but there is no confirmation of this.

(1) Northern bluefin tuna, *Thunnus thynnus* (Linnaeus)

The northern bluefin tuna is the only species among larger tunas for which spawning is mostly in the area. Spawning is in the waters off the east coast of Formosa Island to southern Japan through the Ryukyu/Nansei-shoto archipelago.[3/] This species is the most northerly distributed of the tunas

1/ The fish have been generally categorized as piscivorous. However, they sometimes show a strong omnivorous nature feeding on various cephalopods and crustaceans (Hotta *et al.*, 1955, Alverson, 1963, Kawasaki, 1965).

2/ The coastal tuna fisheries in the Philippines which developed recently, seem to have been intensively harvesting juvenile skipjack and yellowfin tuna (Aprieto, 1982, White, 1982). This may be the first occasion on which juvenile skipjack have been exposed to substantial fishing mortality. This should be taken into account in future studies as the fish taken by the fishery are probably from the same stock(s) as those being exploited further north in the area.

3// It has been reported that substantial spawning occurred in the Japan Sea, along the central to western Japanese coast (Suisankeizai, an industrial newspaper, 30 August 1984).

although it also extends widely offshore in the North Pacific and reaches to the west coast of North America. Catch of this species in the North Pacific Ocean has therefore been taken mostly by the Japanese and Taiwanese fisheries (75-85 percent) from the western Pacific and partly by the U.S.A. and Mexican fisheries (15-25 percent) from the eastern Pacific.

The fish is characterized by a regular long distance trans-Pacific migration in association with their growth. In particular, fish seem to migrate across the northern Pacific Ocean from their nursery grounds along the Asian coast, to the west coast of North America where they grow to age 1-2. After spending 3-4 years in the eastern Pacific Ocean the fish appear to migrate back to the Asian coast. They mature at around age 6-7 at about 160 cm body length and spawn during May to June in the waters referred to above. Matured fish seem to remain in the western Pacific Ocean making seasonal migrations to the north for feeding and to the south for spawning. The catches taken from the west and east Pacific Ocean have completely different age compositions that reflect this migration pattern. Thus, these are juveniles (0-1 ages with 20-80 cm body length)[1/] and adult fish (ages 6 and above with 150-250 cm body length)[2/] in the western Pacific compared with young fish (ages 2-4 with 60-120 cm body length) in the eastern Pacific.[3/] Northern bluefin tuna are also caught in east and west Australian waters, but their relationship with fish in the North Pacific is not clear.

The northern bluefin has the longest lifespan among the larger tunas. Catches of exceptionally large fish, up to 300 cm in length and 500 kg in weight that are probably older than 15 years, have frequently been reported from the Japanese fishery.

Large fluctuations in year-class strength are another characteristic of the fish. This may be due to the relatively limited area and short period of spawning in high latitudes which may make the larvae vulnerable to environmental variations. Because of this, the nominal catch statistics show large annual fluctuations (Table 10), and stock assessments have been hampered. However, it appears that the stock is nearly fully exploited and larger catches with increased fishing may not be expected. The annual potential yield from the entire North Pacific Ocean may be around 10-25,000 t. The stock biomass for this species seems to be the smallest among the larger tunas.

The biological characteristics of northern bluefin tuna, and the fisheries in the Pacific Ocean, were well reviewed recently by Yamanaka (1982).

(2) Albacore, *Thunnus alalunga* (Bonnaterre)

Fish caught in the Northwest Pacific are part of a stock distributed widely in the North Pacific but which seem to be separated from a different stock in the South Pacific. The stock has been exploited by the Japanese, Taiwanese and Korean Rep. fisheries in the Northwestern Pacific and by the U.S.A. and Canadian fisheries in the Northeastern Pacific. The majority of the catch has been taken by troll and pole-and-line in the former waters and by purse-seine in the latter. The catch of albacore has been the largest among the tunas taken from the Northwest Pacific with an annual catch of 40-90,000 t (Table 10).

The fish matures around age 6 at about a 90 cm body length. The catch comprises mostly of age 4 and 5 fish (about 70 percent) in the western Pacific Ocean and age-2 to 4 fish in the eastern Pacific Ocean which clearly shows the strong dependency of fishing on immature fish. The entire stock seems to have been fully exploited, and an increase in catch is therefore not expected either from the entire Pacific or from the Northwest Pacific.

(3) Yellowfin tuna, *Thunnus albacares* (Bonnaterre)

There has been no consensus so far concerning the population structure of yellowfin tuna in the Pacific Ocean. The spawning ground of this species extends widely across the ocean from equatorial waters to semi-tropical waters in both hemispheres without significant disruption. There are two concentrations however, one located around the southern Philippines to the Solomon Islands in the west, the other off Baja California to Central America in the east. There may be substantial mixing of fish originating from these two concentrations. However, for practical purposes, yellowfin tuna in the Central to Western Pacific and in the Eastern Pacific have been usually dealt with separately. The western groups of fish are caught by various countries such as Japan, Taiwan, Province of China,

1/ Incidentally caught by set-net and troll fisheries along the Japanese coast.
2/ Caught by the Japanese and Taiwanese longline, pole-and-line, troll, set-net and purse-seine fisheries.
3/ Caught mostly by the U.S.A. purse-seine fishery off California.

Indonesia, Philippines, Korea Rep. and other coastal countries. Fishing is mostly by longline, pole-and-line and partly by purse-seine. The eastern groups are captured by the U.S.A., Mexico and Ecuador mostly by purse-seine.

These fish mature early starting around age-1 at 60-80 cm body length, and reaching about 50 percent maturity at around age-3 at about 140 cm body length. Body size of the catch varies greatly according to the gear employed. It is 120-170 cm (age-2 to 7) for longline and 50-100 cm (age-0 to 2) for surface gears such as purse-seine and pole-and-line. The recently developed tuna fishing in the Philippines (ringnet, small and large purse-seine) has been mainly exploiting juvenile yellowfin tuna with about 20-50 cm body length (Aprieto, 1982, White, 1982). The total catch of these juvenile fish from the entire Filipino waters in 1980 was estimated to be about 15,000 t or 25 million individuals (White, 1982). The effect of this fishery on the stock as a whole has not yet been determined and an assessment is strongly recommended.

The catch of yellowfin tuna taken by the Japanese and the Taiwanese fishery in similar quantities from the Northwest Pacific, has been fairly constant at about 30-45,000 t annually, during the past decade (Table 10). An assessment of the entire stock has not yet been made but it is believed that the exploitation of the western Pacific groups by the longline fishery may have reached its optimum level around the mid-1960's (Japan, Fisheries Agency, 1974a). The fish in deeper water, which are exploited by longline, appear to have been fully exploited. This is so, even though the fishing intensity has been decreasing slightly in recent years mainly due to economic difficulties in the Japanese fishery as was described in the section on skipjack tuna. The fishing intensity on surface caught fish has, on the other hand, greatly increased during the past decade. A greater catch from the Northwest Pacific is therefore not to be expected in the future. The yellowfin tuna catch from the Western Central Pacific has greatly increased during the past decade from about 18,000 t to 150-180,000 t in association with the rapid development of the coastal fisheries in the region. An assessment of these fisheries is essential as these fish are taken from the same stock as that referred to above.

(4) Bigeye tuna, Thunnus obesus (Lowe)

Bigeye tuna has the widest distribution range among tunas occurring in the Pacific Ocean. It extends from the east to the west and from the tropics to temperate waters in both hemispheres. Spawning takes place widely in equatorial waters. The population structure has not yet been clearly identified. However, it is generally accepted that the fish distributed in the entire Pacific Ocean may form a large single stock though the fish in the extreme north and the extreme south seem to be well separated. The fish appear to change their habitat in accordance with their growth stage and to intermingle gradually with other groups throughout their lifespan. The age at maturity is relatively high, starting around age-2 at about a 90-100 cm body length and reaching 50 percent maturity at around age 4 at body length about 130-140 cm.

The size of the fish taken commercially is different for different fishing gears and grounds mainly due to the migratory habits of the fish. For example, fish taken by pole-and-line in waters around Japan mainly consist of immature fish of about 50-100 cm, while the longline catch taken from oceanic waters in the Northwest Pacific is composed of larger fish of about 100-140 cm. The fish taken by longline from equatorial waters are the largest and are all mature fish about 140-160 cm in length.

The bigeye tuna catch from the Pacific Ocean are taken almost exclusively by longliners (95 percent or more of the total catch) mostly from Japan, Taiwan Province and Korea Rep. The Japanese and Taiwanese operate in the Northwest Pacific, and their combined catch is relatively small amounting to 11-19,000 t annually (Table 10). This accounts for about 11-18 percent of the total bigeye tuna catch from the entire Pacific Ocean. Exploitation of the entire stock seems to have reached its maximum level, with an estimated MSY of about 80,000 t, which was reached around the early 1960's. The fishing intensity appears to have been in excess of this since then (Japan, Fisheries Agency, 1974a). Further increases in catch are therefore not expected and the total catch of 70-110,000 t in recent years may even decrease in future if the fishing intensity is strengthened.

All the tuna species briefly reviewed here are piscivorous or omnivorous and occupy a top trophic level. Interspecific relationships with other species must be highly complicated as has been reported by many scientists, and has been very briefly reviewed in the section on skipjack in this paper. It also appears that intraspecific relationships would probably play a very important role in the population dynamics of the tuna. The author stresses the importance of future studies and he believes that more information about natural mortality, especially during the early life stages, would help to improve the appraisal of fishing mortality.

7.4.3 Smaller tunas, Auxis spp. and Euthynnus affinis (Cantor)

Three species of smaller tunas belongong to the Thunnini are commonly found in southern waters in the Northwest Pacific. These are: (1) the bullet tuna, Auxis rochei (Risso), (2) the frigate tuna, Auxis thazard (Lacepede) and (3) the kawakawa or eastern little tuna, Euthynnus affinis (Cantor). All these fish are considerably smaller than the larger tunas, and common sizes observed in commercial catches are 30-40 cm for the former two species and 40-50 cm for the kawakawa.

(1) Bullet and frigate tunas, A. rochei and A. thazard

It is believed that bullet and frigate tunas must have been harvested in substantial quantities along the southern coast of China including the Taiwan Province (Yang et al., 1977, Yang, 1978). However, statistics are incomplete for catches of these species. The nominal catch from the Japanese fisheries is about 17-23,000 t annually in recent years. However, these figures may be limited to those taken from coastal waters around Japan. It is believed that substantial quantities of these species incidentally caught by the Japanese tuna fisheries in offshore waters are discarded into the sea due to their low market price. The population structure and biological characteristics of these fish are not known. Judging from the wide distribution of the catch and abundance of the larvae, these fish might attain a relatively very large biomass next to that of skipjack, in which case they appear to have been only moderately exploited. Biological information obtained from the world oceans so far has been reviewed recently (Uchida, 1981).

(2) Kawakawa, E. affinis

Information on both the catch and biological characteristics of kawakawa is very sparse. The size of the stock(s) is probably the smallest among the smaller tunas judging from the facts that the fish appear to exhibit a more neritic nature than the others and this may be associated with a limited distribution of local stocks. Also these fish have never made up a large part of the tuna catches taken by surface gears.

Taken as a whole, although they have not been fully exploited and the potential harvest is probably far greater than current catches of about 15-30,000 t (Table 10), and the smaller tunas are unlikely to be intensively harvested by large-scale directed fishing due to a few limiting factors such as small school size, sporadic availability, easy-to-spoil nature of meat and low commercial value etc. However, these resources may become more important in the future in the southern part of the Northwest Pacific, and especially along the Chinese coast. More research on these species should be undertaken in the immediate future.

7.4.4 Billfishes, Xiphioidei

Six species of billfishes[1/] occur in the Pacific Ocean. These are: (1) the swordfish, Xiphias gladius, (2) the striped marlin, Tetrapturus audax, (3) the shortbill spearfish, T. angustirostris, (4) the Indo-Pacific blue marlin, Makaira mazara, (5) black marlin, M. indica, and (6) Indo-Pacific sailfish, Istiophorus platypterus. All these species also occur in the Indian Ocean and swordfish is quite cosmopolitan and is distributed all over the world's oceans. In the Pacific Ocean their distributions extend widely from the tropics to temperate waters in both hemispheres. The proportion of the catch of these species from the Northwest Pacific generally account for 40-50 percent of the total catches from the whole of the Pacific Ocean. The population structure of these fish is not well understood. However there is no doubt that the fish exploited in the Northwest Pacific are only a part of a stock that is widely distributed beyond this area. Detailed assessments for these species will therefore be made in a separate paper covering their entire distribution range.

(1) Swordfish, Xiphias gladius Linnaeus

In the Northwest Pacific, swordfish are distributed as far north as about 50°N, around the northern Kuril Islands. The common size in the commercial catches is 120-190 cm in length although there are reports of larger fish up to 400 cm and 500 kg body weight. These fish feed primarily on pelagic fish including tunas and squids but appear to intake any food items they encounter.

1/ There has been considerable confusion until fairly recently about both the scientific and English names of these species and no firm consensus has been established so far. The names used in this paper are those given in the FAO Species Catalogue Vol.5 Billfishes of the World prepared by Nakamura (1985).

The catch from the area ranges from 7-10,000 t in recent years and this accounts for about 45-55 percent of the total catch from the whole Pacific. The catch has been taken mostly as a by-catch by Japanese and Taiwanese tuna longline fisheries. However, there has also been a directed swordfish longline fishery in Japan due to the high commercial value of this species. The state of exploitation is not clear but more than likely it is probably nearly fully exploited. Biological information obtained from the world's oceans so far has been reviewed recently (Palko et al., 1981).

(2) Striped marlin, Tetrapturus audax (Philippi)

Although the spawning ground of this fish is located in tropical to subtropical waters, they appear to prefer temperate rather than warm waters in the Pacific. The larger fish are concentrated in two belts along 10^{o}-40^{o} north and south in both hemispheres, and the two belts are connected together in the eastern Pacific. It has been generally accepted that the fish in the North Pacific and in the East to South Pacific may be isolated from one another.

The body size commonly found in commercial catches is 130-170 cm although larger individuals of 290 cm with a body weight of 250 kg are occasionally reported. The fish is carnivorous feeding on various pelagic fish species and squids.

The annual catch taken from the Northwest Pacific ranges from 5-7,000 t accounting for 40-50 percent of the total catch from the whole Pacific Ocean. This is the second largest catch among billfishes, following that of swordfish. The fish are mostly taken by the Japanese fishery due to the high commercial value in Japan, but are also taken by the Taiwanese fishery. The fishing gears employed are tuna longline, drift gillnet and harpoon of which the last two are used for directed fishing. The state of exploitation is not clear but has probably reached its optimum level in the North Pacific judging by a substantial decline in the total catch during the early 1970's and the relatively constant catch thereafter.

(3) Indo-Pacific blue marlin, Makaira mazara (Jordan et Snyder)

In the North Pacific Ocean these fish are distributed widely from tropical to temperate waters north to about latitude 45^{o}N, around the east of Hokkaido to the southern Kuril Islands. The fish has a strong oceanic nature and scarcely approaches coastal waters. However, it does migrate occasionally into the Japan Sea taking advantage of the Tsushima Warm Current.

This fish is the largest of the billfishes as individuals with a body weight of 800-900 kg has frequently been reported from commercial catches. The common size in the catch is also large, with body lengths of 200-280 cm in the North Pacific Ocean. It is a typically piscivorous species that feeds intensively on pelagic fish and especially on tunas.

The annual catch from the Northwest Pacific was 5-7,000 t in recent years and this accounted for 30-40 percent of the total catch from the whole of the Pacific Ocean. This catch has mostly been taken by tuna longline fisheries from Japan and Taiwan, Province of China. Small numbers have also been taken by directed harpoon fishing by these countries due to the high commercial value of the fish. The state of exploitation is not clear but it has probably been fully or even slightly overexploited in recent years judging by the gradual but continuous decline in total catch from the entire North Pacific Ocean over the years.

(4) Black marlin, Makaira indica (Cuvier)

The latitudinal range of the distribution of black marlin in the North Pacific Ocean is narrower than that for the other billfishes, extending north to around latitude 40^{o}N in the Northwest Pacific, around the central to northern Honshu of Japan. Black marlin are oceanic in nature, similar to other billfishes, but frequently approach coastal waters especially along the Japanese coast.

Black marlin may be the second largest billfish in body size, after the Indo-Pacific blue marlin, since it attains a maximum size of about 450 cm with a body weight of 700 kg. This fish is also typically piscivorous feeding intensively on pelagic fish including tunas.

The total quantity of the fish commercially taken from the area is not clear as the nominal catch by the Japanese fishery is not available for this species although the nominal annual catch by the Taiwanese fishery ranges from 2-3,000 t. The total catch is probably more than double this as it is believed that the Japanese catch is substantially greater than that of the Taiwanese fishery. The major fishing gears employed are directed billfish longline (Japan) and tuna longline (Japan and

Taiwan, Province of China). Minor ones include directed harpoon fishing (both countries) and coastal setnet (Japan, incidental catch). The state of exploitation is uncertain due to the incomplete catch statistics mentioned above. However, it is quite likely that the fish in the North Pacific Ocean may have been exploited to the same extent as the Indo-Pacific blue marlin judging from circumstantial evidence, i.e. the stock was probably fully exploited due to its high commercial value and this resulted in intensive directed fishing.

(5) Indo-Pacific sailfish, Istiophorus platypterus (Shaw et Nodder)

The distribution range of Indo-Pacific sailfish covers a wide range of latitudes in the North Pacific Ocean and extends north to about latitude 50^{0}N, around the northern Kuril Islands. The fish migrate into the Japan Sea and often approach coastal waters along the Japan Sea and Pacific coasts of Japan.

The size of fish taken by the commercial fisheries varies greatly according to region and fishing gear and ranges from 140-240 cm in length. Food preference appears to be the weakest among billfishes feeding on various pelagic fish and squids.

The annual catch from the Northwest Pacific was 3-5,000 t in recent years caught mostly by the Taiwanese and partly by the Japanese fisheries. The fishing gears employed are tuna longline, drift gillnet, harpoon and coastal setnet, all gears except for harpoons, catching fish as incidental by-catches. The state of exploitation is not clear but is probably approaching the optimum level.

(6) Shortbill spearfish, Tetrapturus angustirostris Tanaka

The distribution extends over a narrow range of latitudes, north to about 30^{0}N in the North Pacific Ocean, around the northern Ryukyu/Nansei-shoto archipelago. The shortbill spearfish is entirely an oceanic fish and never approaches the coast.

The common body size in commercial catches is relatively small, compared with other billfishes at 130-150 cm and it appears to feed on most of the animals it encounters.

The fish has the lowest commercial value among billfishes and no directed fishing has been attempted. The quantities caught are unknown as no country has separated the fish in its national statistics. It is said that the Japanese catch from the whole Pacific Ocean has been very small, amounting to several tens or several hundreds of tons at most. This may reflect a relatively small biomass and a low fishing effort due to the low market price of the catch. The state of exploitation is completely unknown.

As briefly described in the above sub-sections, billfishes are characterized, in addition to their generally highly migratory nature, by their large body size and high trophic level, especially in the pelagic fish community. They do not have many competitors for food and space at the adult stage; they are probably limited to other billfishes, larger tunas, larger pelagic sharks and a few toothed whales (killer whales and possibly dolphins). The predators on adult billfish are further limited to toothed whales and possibly the larger pelagic sharks.

It is likely that there is a very large predation by billfishes on other pelagic fish species, and especially on skipjack tuna and the larger tunas. Almost no studies have been carried out so far concerning this, but it would be very useful to estimate the extent to which skipjack and the larger tunas are eaten by billfishes.

Information on the inter- and intra-relationships of billfishes at their early stages (larvae-fry-juvenile) are almost non-existent. Direct research on these aspects will be extremely difficult to carry out. However the continuous accumulation of data obtained through research directed at other resources, no matter how fragmentary, is highly desirable in the future.

7.4.5 Summary for tunas and billfishes

Almost all the resources occurring in the Northwest Pacific are parts of large stocks that extend beyond the Northwest Pacific area with a few exceptions of the local stocks of smaller tunas. Assessments therefore need to be made covering the entire distribution ranges of these fish, and this is beyond the scope of this paper. However, the author presents here a brief summary of the state of exploitation and comments on the biological features which need to be studied in future for management purposes.

It now seems likely that most of the tuna and billfish resources are fully exploited even if the waters outside the Northwest Pacific are taken into account. The only exceptions are skipjack tuna and the smaller tunas which may still be underexploited. However, as far as skipjack in the Northwest Pacific are concerned fishing seems to have extended to all the available fishing grounds and it is unlikely that there will be an increase in the number of recruits migrating into the area from the south. More of the smaller tunas could be harvested with an increase in fishing effort, but this may have to be limited to waters along the southern Chinese coast.

Taken as a whole, the total production of tunas and billfishes from the Northwest Pacific has nearly levelled off to about 280-380,000 t annually, made up of skipjack tuna: 130-170,000 t; larger tunas: 100-130,000 t; billfishes 20-30,000 t; and smaller tunas: 30-50,000 t for which only an increase of about 20-30,000 t is expected. Management of these resources on a regional and inter-regional basis is therefore the most important subject to be tackled in the future. For instance, if skipjack fishing in the south is expanded beyond the optimum level, recruitment to the Northwest Pacific is likely to decrease or the total production from the entire resources may also decrease. Unfortunately, so far, there is no international organization in the Western Pacific to deal with the global management of tuna resources comparable with IATTC[1/] or ICCAT[2/] and it is unlikely that such an organization will be established in the immediate future due to the highly complicated political situation and the intricate structure of the fisheries in the region. It is advisable, at present, to strengthen cooperative research through the IPFC[3/] and to explore suitable methods of management. The major line to be employed in future research and international collaboration should be as set out at the international workshop held recently at the NMFS, Honolulu Laboratory[4/] (NMFS, Honolulu Laboratory et al., 1979).

An important biological characteristic of this species group is its high trophic level which also influences the natural mortality rate of other pelagic resources. Further research on inter-specific relationships are highly recommended in the future. Studies of intra-specific relationships, especially relating to larval-juvenile mortality caused by cannibalism, also appears to be of considerable importance as briefly discussed in the section on skipjack. More comprehensive data collection and analysis in this connection is highly desirable. Needless to say, international collaboration in research in these fields, including traditional stock assessments, must undoubtedly help towards the rational utilization of these resources concerned.

7.5 Cephalopods[5/]

The total cephalopod catch from the Northwest Pacific has been about 700-900,000 t in recent years (Table 5-(1)) which is about double that of Japanese anchovy. Many studies of the biological characteristics of these species have been carried out in Japan and in this paper a brief review by species group is presented.

7.5.1 Squids

The total squid catch has been almost constant during the past 20 years at about 500-600,000 t annually (Table 11, Appendix Table 20 (1 and 2)). However, the composition of the catch has changed greatly during the past decade, due to a significant decrease in the catch of Japanese flying squid and a remarkable increase in that of oceanic squids.

(1) Japanese flying squid, *Todarodes pacificus* (Steenstrup)

Japanese flying squid are abundantly distributed in the western part of the Northwest Pacific. Concentrations of squid are found in both warm and cold water around Japan. For example, they are found in the eastern East China Sea, where the Kuroshio and Tsushima Warm Current prevail and they spawn,in the south and in the southern Okhotsk Sea and Pacific Ocean along the southern Kuril Islands

1/ Inter-American Tropical Tuna Commission, (for the eastern Pacific Ocean, La Jolla, U.S.A.).
2/ International Commission for the Conservation of Atlantic Tunas, (for the Atlantic Ocean, Madrid, Spain).
3/ Indo-Pacific Fisheries Commission.
4/ NMFS Honolulu Laboratory: National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory.
5/ The English names of many cephalopod species have not been standardized until recently. The names included in this paper, including scientific names, are referred to those defined in the FAO species catalogue on cephalopod recently published (Roper et al., 1984).

Table 11

Catch of cephalopod by species group during 1970-81.1/

(1) FAO Statistics

('000 t)

	1970	1975	1976	1977	1978	1979	1980	1981
Japanese flying squid	484	399	326	226	234	239	379	228
Other squid	69	137	194	247	315	361	378	338
Cuttlefishes2/	27	36	54	47	68	88	70	66
Octopuses	49	58	51	48	52	50	55	53
Total	629	630	625	568	669	738	882	685

1/ Catch by Korea D.P. Rep. is not known.
2/ Catch statistics for China are not available although a substantial quantity of cuttlefish has been commercially taken.

(2) Estimated total catch of cuttlefishes.3/

('000 t)

	1970	1975	1976	1977	1978	1979	1980	1981
Cuttlefishes	72	69	83	79	118	160	134	89

3/ Source: Chikuni (1983), estimates for Chinese catches are included.

where a cold water regime prevails, in the north through the entire Japan Sea and the Pacific coast of Japan. Squid have been traditionally and intensively utilized by the Japanese fishery partly due to consumer acceptability and partly because it is easy to process and preserve. For example, dried squid has been popular since ancient times.1/ Because of its importance, numerous studies of the biology of the squid have been carried out in Japan. Among these contributions, fairly comprehensive and updated reports are: Hidaka et al., (1972), Japan, Fisheries Agency, (1973d), FAO (1976), Okutani (1977) and Osako et al., (1983). A review of the squid resources will be briefly made in this paper avoiding detailed repetition of the above-mentioned papers or numerous individual reports.

Flying squid around Japan comprise three different spawning groups. There are summer, autumn and winter spawners with different life cycle2/ patterns. The major spawning grounds of

1/ The Japanese name for the dried product, "Surume-Ika" has become the common name for squid in both the industrial and public sectors of Japan.
2/ Each group has generally been dealt with as an independent stock by Japanese scientists. The author, however, deals with them as spawning groups in this paper as the degree of mixing between the successive spawning groups is uncertain.

these three groups are located in almost the same area, extending from the East China Sea to the south and western coasts (both the Pacific and Japan Sea) of Japan. As they grow they migrate to the north through both the Japan Sea and along the Pacific coast of Japan to feed. The trans-regional migration from the Japan Sea to the Pacific Ocean through the Tsugaru Strait and to the Okhotsk Sea through the Soya Strait, and vice-versa, is particularly noticeable for the winter group. After about one year for feeding in the northern region, the squid mature and return to their original spawning ground. All individuals die after the first spawning.

The winter group has the largest biomass and the most extended migration range from which the largest catch has come. This has mostly been taken along the Pacific coast of Japan. The annual catch from this group reached about 300-400,000 t during the mid 1960's but since 1969 has declined substantially.

The autumn group has the second largest biomass and mostly inhabits the Japan Sea where they are caught mostly by the Japanese and partly by the Korea Rep. fisheries. The total catch from the group reached a peak of about 260,000 t (206,000 t by Japan and 53,000 t by Korea Rep.) in 1972 but since then has steadily declined.

The summer group is subdivided into two independent local groups, along the Pacific and Japan Sea coasts of Japan respectively. These have been harvested almost exclusively by the Japanese. Both sub-groups have a very small biomass and the total catch from these groups has been very small, usually accounting for less than 5 percent of the total squid catch or 10-30,000 t annually. The abundance of these sub groups appears to have been fairly stable at a relatively low level until the mid-1970's. The recent trend is not clear, but is probably a declining one, as with the other groups.

The total catch of Japanese flying squid from the whole area, for all three groups combined, has been large for a single species amounting to 400-500,000 t during the 1950's-60's (Figure 30, Appendix Table 20(1)). This is far greater than the catch of Pacific saury for example (Appendix Table 12) and nearly equivalent to that of Japanese anchovy (Appendix Table 14-(1)). The catch has been taken by the Japanese and by the Korea Rep. The Japanese fishery developed considerably soon after World War II due to a remarkable improvement in the fishing technique. This involved the installation of multi-hooked reels, and this development was followed by mechanization of the operation a few years later. As a result, fishing efficiency became very much higher than it had been with traditional angling methods. Night time fishing was also introduced on a large scale at the same time associated with the success in luring squid by large lights on board. The use of acoustic instruments also contributed to the improvement in fishing efficiency, as did also an expansion of fishing grounds to offshore waters. The average vessel size in the Japanese offshore squid jigging fishery has increased and is now about 65 GTS, and all of these operate the above mentioned fishing gears. The total Japanese catch of squid, as a result, increased remarkably around the late 1940's from a pre-war level of about 5-15,000 t to a post-war level of 400-500,000 t. The catch by the offshore jigging fishery with mechanized fishing gears usually accounts for about 90-95 percent of the total catch in Japan. The Korea Rep. fishery adopted a similar gear a few years later. The average vessel size of the Korean Rep. offshore squid jigging fishery is now about 58 GTS. These engage in the Japanese type night fishing as described above and usually catch more than 80 percent of the total flying squid catch by the Korea Rep. However, it should be noted that the Korean Rep. catch has shown a significant decline since the early 1970's in spite of the continuing modernization of the fisheries (Kim et al., 1981a).

According to various reports, there is little doubt that the total squid stock, for all three groups combined, had only been slightly exploited during the pre-war period. It has been generally accepted by those scientists that rapid intensification of fishing since the late 1940's resulted in heavy fishing: firstly, on the winter group during the 1950's-60's (Araya, 1974, Okutani, 1977) and secondly, on the autumn group during the mid 1960's to early 1970's (Japan, Fisheries Agency, 1976b, Okutani, 1977). Fishing might have exceeded the optimum level around 1967 for the winter group and around 1972 for the autumn group (Ibid.). This would have resulted in a significant decline in the spawning stock and the amount of spawning during the early 1970's for the former group (Japan, Fisheries Agency, 1976b) and during the mid 1970's for the latter (Okutani, 1977). As a result the abundance of both groups has further declined, and the total catch has accordingly decreased significantly since the early 1970's. It was expected that with a reduction in fishing intensity the abundance of the stock would increase and the catch would recover (Okutani, 1977, Osako et al., 1983). In the meantime, a substantial amount of fishing effort on Japanese flying squid has been shifted to catching oceanic squids since the mid 1970's, which will be discussed in the next item in this subsection. However, there has been no clear sign so far of a recovery in either the abundance or the catch of Japanese flying squid around Japan (Figure 30, Appendix Table 20(1)).

Traditional angling by hand. The crew engages in handlining while the automatic handliners are in operation. A machine is shown in the background.

A small-scale automatic handliner in operation.

PHOTOGRAPH 9. Catch of Japanese flying squid by small-scale squid jigging of the Touni-cho Fisheries Cooperative, the northern Pacific coast of Hunshu, Iwate prefecture. Vessel size is usually very small, of about 3-5 GRT, but well designed. They carry navigational and fishing equipment including luring lights, a generator, acoustic fish finder, automatic handliners and holding tanks for the catch.

Photograph taken by S. Ohtake (Yamaha Motor Co. Ltd., 1978).

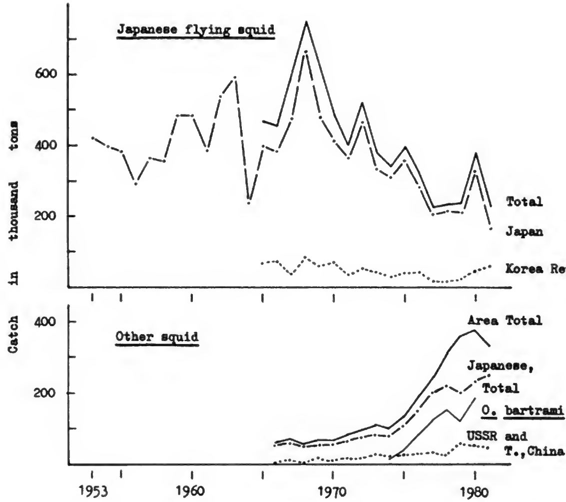

Figure 30. Catch of Japanese flying squid and Other squid by country including the Japanese catch of an oceanic squid, Ommastrephes bartrami. See Appendix Table 20 (1 and 2) for statistics.

T., China : Taiwan, Province of China

In contrast to the view expressed above, the author is inclined to think that the change in abundance in flying squid stocks is probably irreversible and that the causes are similar to those that affected the coastal pelagic fish stocks. In other words, a change in the natural mortality during the early life stages may for some reason have played a much more important role in the population dynamics of the stock than a change in fishing mortality. In fact, a medium term (with a 7-9 years period) fluctuation in abundance can be observed in the catch record throughout history and including the pre-war period when fishing was limited to nearshore waters (Japan, Fisheries Agency, 1973d). A study recently carried out of the relationship between the parent stock and the number of larvae, has revealed that there have been many occasions in which no clear relationship could be found (Okutani et al., 1983a). For example, in 1960 the abundance of larvae was very low even though the parent stock was quite large. In 1964 on the other hand the parental stock size was very small yet the abundance of larvae was extremely high. Similar results have been found for Japanese chub mackerel and Japanese sardine. However, the causes of the underlying processes involved in these relationships are not clear. The squid, in contrast to mackerel or sardine, complete their life cycle within one year and reproduce only once. The underlying process may therefore be different from those in mackerel or sardine. Further studies are highly desirable and research in interspecific relationships with food species and predators should also be intensified.

It may be prudent when the stock is declining, to establish a catch limit at a certain level, such as for example 300,000 t, for the same reasons as for coastal pelagic fish stocks. The total potential harvest from the whole stock could be about 300-400,000 t. The larger annual catches of 400-500,000 t taken during the 1960's may have exceeded the sustainable yield.

(2) Oceanic squid

(a) Northern region

Three species of oceanic squid became commercially important in northern waters in the Northwest Pacific, 40-45°N, from east of the northern Honshu of Japan to the southern Kuril Islands, since the early 1970's. These are (i) neon flying squid, Ommastrephes bartrami (Le Sueur), (ii) boreal clubhook squid, Onychoteuthis borealijaponica Okada and (iii) boreopacific gonate squid, Gonatopsis borealis Sasaki. All three species are distributed widely across the North Pacific Ocean. The distribution range of neon flying squid covers a wide range of longitudes, from tropical to boreal waters. The other two species are limited to northern waters. Not much is known about the biological features of these species due firstly to their oceanic nature and secondly to the very short history of their exploitation. However, information on their biology and fisheries are well documented in the following papers: Murata et al., (1976, 1980, 1982), Murakami (1981), Naito et al., (1977, 1977a), Okutani (1977, 1980), Okutani et al., (1983), Kubodera et al., (1983), Osako et al., (1983), Tung (1981).

Although it was well known for many years that these species were widely distributed in offshore waters off the Pacific coast of northern Japan they had not been utilized commercially until recently due to the low commercial value of the catch. This is because of the harder texture and garish body colour of the species. However, since around 1970 due to the sharp decline in the abundance of Japanese flying squid especially of the winter group, Japanese fishermen, and especially those along the northern Pacific coast of Japan, began to pay attention to harvesting them. Fishing on these species was commenced in the early 1970's supported by the development of new processing techniques for favourable products resembling those of Japanese flying squid. Among the three species being exploited, neon flying squid, O. bartrami appears to have attained the largest biomass and the highest availability. The catch of this species of squid has rapidly increased within a few years and has become nearly equivalent to that of Japanese flying squid with about 200,000 t annually (Figure 30, Appendix Table 20-(2)). The other two species, boreal clubhook squid, O. borealijaponica and boreopacific gonate squid, G. borealis are minor in terms of commmercial availability. The annual catch of these species has been very small, usually less than 100 t in recent years (Appendix Table 20-(2)).

These squid have been harvested intensively by the Japanese and partly by the Taiwanese fisheries by means of jigging and surface gillnetting (Appendix Table 20-(2)). The catch data from the USSR fishery are not available but catch of these squid may probably be substantial in recent years.

The fishing ground extends eastward from the offshore waters of northern Japan and the southern Kuril Islands to the central part of the northern North Pacific beyond the eastern border of the area. It should be noted, in this connection, that O. bartrami (warmer-water type), O. borealijaponica and G. borealis (both cold-water type) have been caught at the fringe area

of their distribution range, northern fringe for the first species and southern fringe for the latter two, where the sharp thermal front/cline is formed by warm and cold-water masses. This implies that the availability of these resources for exploitation may be limited to specific regions even though they are widely distributed in the ocean. Due to the lack of information a proper assessment for these species is difficult to make at this stage. However, Okutani (1977) gave preliminary estimates of the potential harvest. These are: 380,000 t for O. bartrami, 130,000 t for O. borealijaponica and 6,000 t for G. borealis. Osako et al., (1983) estimated that the potential harvest of O. bartrami in the waters west of 170°C (west of the longitude running along the Komandorskye Islands) would be 80-100,000 t.[1/] The author has doubts about the interpretation of these assumptions, and thinks that the former estimate is too large (about 520,000 t with all the species combined) and the latter too small (100,000 t plus the minor two species) when the history of the fisheries during the past 7 years is taken into account. The potential harvest of the northern oceanic squids is therefore likely to be around 250-350,000 t on a more conservative basis, and an increase in catch can therefore be expected with greater fishing effort. However, the actual catch will be greatly affected by the availability of squid in connection with the oceanographic conditions on the fishing grounds.

It is known that another oceanic squid, schoolmaster gonate squid, Berryteuthis magister (Berry) is widely distributed in the northern region of the area. This species is characterized by a unique life-form. At a certain stage (probably at around the 10 cm mantle-length) they move to the bottom of the sea, usually on the continental slope at a depth of 200-500 m, and then take up a sedentary habit thereafter (Naito et al., 1977). Catches therefore come from the trawl fishery and are reported as by-catches along northern Japan and the western Bering Sea (Ibid., Osako et al., 1983). This species is not likely to be intensively exploited by directed fishing.

(b) Southern region

Purpleback flying squid, Symplectoteuthis oualaniensis (Lesson) has been traditionally harvested in the eastern and southern East China Sea, from Formosa Island to Ryukyu/Nansei-shoto archipelago, although the catch has been quite small at about 300-400 t (Okutani et al., 1978, Chikuni, 1983). This species is caught by hook-and-line with light and small-scale mechanized jigging by the Okinawan and Taiwanese fisheries. It is interesting to note that they are caught in substantial quantities in coastal waters in the Formosa Strait (Tung et al., 1973) although they are highly oceanic in nature. The population structure and the details on the life history of the squid are not known. It is quite likely that the biomass of the entire stock is immense. However, commercial fishing is severely limited by oceanographic conditions and by their behaviour, to areas where significant concentrations of squid occur. The above-mentioned regions may be one of the waters where conditions rarely are suitable for fishing. It is doubtful therefore that substantially greater catches would be taken even if greater effort were to be expended.

Another warm-water species of oceanic squid, the diamondback squid, Thysanoteuthis rhombus Troschel has been caught in the waters around Japan. However, fishing is very localized and sporadic as they generally do not form dense schools but are occasionally caught by setnets along the central Japan Sea coast of Japan. The total catch of squid from the area is not known, but is probably very small, and of the order of several hundreds of tons at the most.

No record of commercial catches of another warm-water species O. bartrami, which has been substantially harvested in the northern region of the area, has been reported from the southern region. This, together with the distribution of catches of S. oualaniensis and T. rhombus, is consistent with the very localized availability of the oceanic squids.

(3) Neritic squids

The total catch of neritic squid, excluding Japanese flying squid, has been fairly constant during the past 15 years at about 70-100,000 t annually (Appendix 20-(2)). The catch is composed of various species locally caught and no single species predominates. Major species exploited and their localities[2/] are: Japanese squid, Loligo japonica Hoyle, (RJ-YS-ES), spear squid, L. bleekeri Keferstein, (RJ), swordtip squid, L. edulis Hoyle, (SJ-WJ-EC-SC), budo squid, L. edulis budo Wakiya et Ishikawa, (WJ), Indian squid, L. duvauceli Orbigny (EC-SC), long barrel squid, L. singhalensis

1/ Relationship with squid further east and south is not clear.
2/ Abbreviations: RJ: Around Japan, NJ: Northern Japan, CJ: Central Japan, SJ: Southern Japan (Pacific coast), WJ: Western Japan (West of Kyushu and Japan Sea coast), YS: Yellow Sea, ES: East China Sea, SC: South China Sea, BS: Bering Sea, OS: Okhotsk Sea.

Ortmann, (SC), sparkling enope squid, Watasenia scintillans (Berry), (RJ and entire Japan Sea) and bigfin reef squid, Sepioteuthis lessoniana Lesson, (RJ-EC-SC).

They are caught by various gears, such as jigging, hook-and-line, troll, trap, gillnet, purse-seine (various types), beach-seine and setnet for directed fishing. The catch by trawl is also considerable especially along the Chinese coast.

The catch of all species combined from the waters around Japan has been at about 20-30,000 t annually. Precise assessments for these resources are difficult to make, due firstly to the lack of detailed catch data and secondly to the complicated nature of the fishery. However, it generally appears that each of the stocks may have been fully exploited at a certain level throughout the years as there have been no significant long-term trends in the catches so far.

The catch statistics for the Chinese (mainland provinces) are incomplete.1/ The estimated Chinese squid catch is about 10-20,000 t annually which appears to be very inactive fishing on squid resources along the coast (Chikuni, 1983). In contrast, Hong Kong and Taiwanese fisheries have been quite active at catching squid in the same region and yielding about 5-6,000 t2/ and 10-30,000 t3/ respectively. Most of the catch by these fisheries is caught by trawls, both directed at particular seasons and as a by-catch in other seasons. Directed purse-seining is also employed in Hong Kong during May-September for catching L. duvauceli and S. lessoniana. In addition to these two species, L. chinensis, L. eduris and L. japonica may make up the major resources being harvested by the Hong Kong and Taiwanese fisheries. They appear to be abundantly distributed in the East China Sea to the northwestern South China Sea. However, it appears that most of the squid stocks in the southern region, with the exception of T. pacificus in the north, have generally been only moderately exploited since the pelagic forms of squids have been scarcely harvested. The potential harvest of squid resources in the region is far greater than the current catch and the increase in the catch in the future is therefore expected with further intensified effort probably doubly or even more (Chikuni, 1983).

It is a distinctive feature of the Yellow Sea where only L. japonica is present in substantial quantities among the major squid species.

7.5.2 Cuttlefishes

Nominal catch statistics of cuttlefish taken from the Northwest Pacific are incomplete (Table 11-(1)), as there has been no catch reported in the statistics from China (mainland provinces). Nevertheless many scientific papers published in China report that several tens of thousands of tons of cuttlefish have been commercially harvested annually along the northern coast. Estimates of annual total catches of cuttlefish based on these reports are given in Table 11-(2).

Major species and their localities4/ are: Japanese spineless cuttlefish, Sepiella japonica Sasaki, (CJ-YS-EC), needle cuttlefish, Sepia aculeata Orbigny, (SJ-WJ-ES-SC), golden cuttlefish, S. esculenta Hoyle, (WJ-ES-SC), kobi cuttlefish, S. kobiensis Hoyle, (SJ-WJ-ES-SC), broadclub cuttlefish, S. latimanus Quoy et Gaimard, (WJ-ES-SC), kisslip cuttlefish S. lycidas Gray, (SJ-WJ-EC-SC), pharaoh cuttlefish, S. pharaonis Ehrenberg, (SJ-WJ-EC-SC), curvespine cuttlefish, S. recurvirostra Steenstrup, (EC-SC). It is noted that all the commercially important species are distributed in the warmer waters with the exception of Sepiella japonica which inhabits both warm and cold waters including the Yellow Sea.

The catch of Japanese spineless cuttlefish, S. japonica is prominent among the major species, probably accounting for 40-50 percent of the total cuttlefish catch from the area (Chikuni, 1983). S. japonica is characterized, in addition to its large biomass, by its eurythermal nature and its abundant distribution in the Yellow Sea where no other significant cephalopod resources exist. The greater

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1/ Although about 30-100,000 t of squid catch have been reported in the nominal statistics, the majority probably consists of cuttlefish as was discussed previously (Chikuni, 1983), and will be discussed again under this subsection.

2/ The absolute amount is not large but it accounts for about 4 percent of the total Hong Kong catch and is equivalent to the catches of the major fish species.

3/ Accounts for 4-8 percent of the total Taiwanese catch from coastal and offshore waters along the mainland coast.

4/ See footnote to the previous sub-section on neritic squid for an explanation of the abbreviations.

part of the catch of S. japonica is taken by the Chinese fishery (chiefly by trawl and partly by trap, setnet and sail dragnet) along the northern Chinese coast. These catches appear to have been taken from several local stocks in the region. The Japanese offshore trawl fishery also exploits the same stocks on the continental shelf in the Yellow Sea and East China Sea. The total annual catch from these stocks fluctuates within the range of 30-70,000 t. The major stocks appear to have been fully exploited since around the late 1950's (Chikuni, 1983). The relationship of these stocks with cuttlefish occurring around the central to western/southern parts of Japan is not clear. The stocks around Japan have been taken by the Japanese coastal fisheries using various gears, and probably represent isolated local stocks. These also seem to have been fully exploited.

Golden cuttlefish, S. esculenta is the next most important species in terms of the quantity caught in the Northwest Pacific. Although the nominal catch statistics have not been recorded separately for this species, it is estimated that about 15-30,000 t has been taken from the entire area, of which about 10-20,000 t has come from the southeastern Yellow Sea to the northern South China Sea through the East China Sea by the Japanese, Korean Rep., Chinese (mainland and Taiwan provinces) and Hong Kong trawl fisheries (Chikuni, 1983), and about 5-10,000 t from the coastal waters around Japan. It is noted that from the Seto Inland Sea, where highly neritic conditions prevail, the catch has been the largest in Japan accounting for about 70-80 percent of the total Japanese catch. The fishing gears employed in the Seto Inland Sea are small-scale dragnet for by-catches, and traditional hook-and-line and troll for directed fishing. Most of the stocks of S. esculenta appear, as in the case of S. japonica, to have been fully exploited since around the 1950's (Chikuni, 1983).

Three other large-bodied species of commercial value, S. pharaonis, S. lysidas and S. aculeata have also been quite intensively exploited due to their high commercial value. These are mostly taken by trawlers as a by-catch in the southeastern Yellow Sea and East China Sea. These species are probably more abundantly distributed in the northwestern South China Sea, but details of the fisheries are unknown except for Hong Kong which carries out an intensive fishery. The state of exploitation is not clear, but the stocks are probably nearly fully exploited in the north and moderately exploited in the south. Another large-bodied cuttlefish S. latimanus is widely but sparsely distributed in the southern region. A further intensification of fishing appears to be difficult due to its particular distribution pattern.

Two smaller-bodied cuttlefish, S. recurvirostra and S. kobiensis, which are abundantly distributed in the southern region, appear not to have been intensively fished except for the local stocks around Hong Kong (Chikuni, 1983). The potential yield of these species is not known, but greater catches may be expected, especially for the latter species.

Taken as a whole, cuttlefish resources generally appear to have been fully or nearly fully exploited with the exception of the smallest (7 cm in mantle length) bodied species, S. kobiensis. A significant increase in the cuttlefish catch, therefore, is unlikely in future, and may amount to a few tens of thousands of tons at most (Chikuni, 1983).

7.5.3 Octopuses

The nominal catch of octopus from the Northwest Pacific has been fairly constant at about 50-60,000 t annually during the past decade (Table 11-(1)). These have been almost exclusively exploited by the Japanese fishery in the waters around Japan and partly by the Korean Rep. fishery along the southern Korean Peninsula. The catch from the southern region has been negligible though several species of octopus appear to be abundantly distributed in the region.

Major species occurring in the Northwest Pacific are[1/]: common octopus, Octopus vulgaris Cuvier, (RJ-EC-SC), a cosmopolitan around the world, chestnut octopus, O. conispadiceus (Sasaki), (OS-NJ), North Pacific giant octopus, O. dofleini (Wulker), (BS-OS-RJ-YS-ES), "Tenaga octopus"[2/], O. minor (Sasaki), (RJ) sandbird octopus, O. aegina Gray, (SJ-YS-SC), webfoot octopus, O. membranaceus Quoy et Gaimard, (CJ-SJ-WJ-ES-SC), white-spotted octopus, O. macropus Risso, (ES-SC), old woman octopus, Cistopus indicus (Orbigny), (SC).

1/ See footnote on neritic squid for the abbreviations of localities.

2/ "Tenaga Dako": long-arm octopus in Japanese.

PHOTOGRAPH 10. Catch of octopus by traditional pot fishing by a small-scale fisherman who is a member of the Toushi Fisheries Cooperative, Ise Bay, central Pacific coast, Mie prefecture. The vessel size is very small, of about 3-5 GRT, and the equipment is simple. Vessels carry a line hauler and holding tanks to keep the catch alive. Fishing by a couple as shown in the picture or with other family members is quite common. The catches are processed (boiled or steamed and iced) for sale usually in the complex of the Cooperatives to which the fishermen belong.

Photograph taken by K. Asako (Yamaha Motor Co. Ltd., 1981).

The total Japanese octopus catch has been constant throughout the years with an annual catch of about 40-50,000 t, of which about 50-60 percent is composed of the the two major northern species, North Pacific giant octopus, O. dofleini and chestnut octopus, O. conispadiceus. They are caught mostly in the waters around Hokkaido (Sakamoto, 1976, Yamashita, 1976), by various gears such as bottom longline, hook-and-line, trap for directed fishing[1/] and are also taken as by-catches in trawls.

Common octopus, O. vulgaris is the next most important species in Japan. The total Japanese catch is estimated to be about 10-15,000 t which is similar to the catch of golden cuttlefish. The largest catch has been taken from the narrow Seto Inland Sea where conditions are strongly neritic with about 6-10,000 t annually. This accounts for about 60-70 percent of the total Japanese catch even though octopus is widely distributed in other regions. They are taken by trap (15 percent), and hook-and-line (20 percent), as aimed fishing and small-scale dragnet (60 percent as by-catch in the Seto Inland Sea (Itami, 1976). Fishing for octopus, including other species and in other regions, has been strictly regulated in Japan by a licensing scheme and by coordination through cooperatives (Asada et el., 1983). Most stocks of common octopus around Japan seem to have been fully exploited and several local authorities are undertaking octopus farming programmes to enhance production (Itami, 1976).

Webfoot octopus, O. membranaceus and "Tenaga octopus", O. minor are also intensively caught in Japan. This is by directed fishing for the former species (small traps made of terracotta or spiral shells are used) and as bycatch for the latter. The catch of these species, especially the former is significant in the narrow Seto Inland Sea, and they have probably been fully exploited.

The total catch of octopus by the Korea Rep. was substantially increased during the early 1970's from about 3,000 t to 7-8,000 t and has remained constant since then. These are caught mostly by bottom longline and trap. The species composition of the catch is not known but probably resembles that of central to southern Japan. That is, a mixture of two major species O. vulgaris and O. minor, and a minor proportion of two cold-water species, O. dofleini and O. conispadiceus in the northern region. It appears that octopus fishing has been less important in the Korea Rep. since the total catch has been rather small in spite of the supposedly large biomass. A large part of the landings (50-60 percent), including those from distant waters, has been exported to foreign countries (Hotta, 1983) and domestic demand is presumably not large enough to stimulate the development of local fisheries.

The catch by Korea D.P. Rep. is not known, but is probably similar to, or even less than that for the Korea Rep. A substantial increase in the octopus catch with increased effort should therefore be possible from the entire coast of the Korean Peninsula. The regions further south (Yellow Sea, East China Sea and northwestern South China Sea) appear to be the least inactive for octopus fishing. Information is limited to the small amount of bycatch by the Taiwanese trawl fishery (nominal statistics) and small-scale directed fishing by trap in Hong Kong (Voss et al., 1971). The species composition of these catches is not known. Common octopus, O. vulgaris appears to be abundantly and widely distributed in the region and has been taken as a small but consistent by-catch by the Japanese offshore trawl fishing on the continental shelf in the region. Other species that appear to have a substantial biomass in the region are: O. aegina, O. dofleini, O. macropus, O. membranaceus and C. indicus. All these stocks seem to have been only slightly exploited or even untouched along the Chinese coast. The potential harvest for all species combined, could be quite large, and probably of the order of several tens of thousands of tons at least (Chikuni, 1983). Larger catches of these species could therefore be achieved by introducing suitable fishing methods, such as trap, hook-and-line or bottom longline, into the region.

7.5.4 Summary for cephalopods

It appears that the cephalopod resources around Japan have generally been fully exploited with the exception of northern oceanic squids. The most important resource, in terms of both quantity and commercial value, Japanese flying squid, has declined during the past decade to about one third of its level during its prosperous period. The reasons for the decline may be chiefly natural though it is difficult to be certain at this stage. Further research on the causes of changes in the abundance of Japanese flying squid is highly desirable, particularly with reference to density independent factors as suggested by Okutani et al., (1983a). This stock may also be influenced by interactions with other pelagic fish. It is well known that squid has an important role in the pelagic community both as a

1/ These gears are well documented in Yajima et al., (1976).

predator (on smaller pelagic fish) and as a prey (for larger pelagic fish). In addition to these direct relationships competition for food and space must be important and highly complicated and variable. Further research is needed in the future. If the catch of Japanese flying squid recovers and is maintained at the 300-400,000 t level, and the potential harvest of northern oceanic squids is estimated to be about 250-350,000 t, the total potential harvest of these two species groups would be about 550-750,000 t annually which is equivalent to the current total catch of cephalopod.

It appears, on the other hand, that the squid resources in the southern region have not been fully exploited and a two-fold or three-fold increase of the current catch can probably be expected in the future. This could lead to about 70-100,000 t annually from the region on a conservative basis. The total potential harvest of squid resources from the entire Northwest Pacific would, taken as a whole, be of the order of 710-950,000 t[1/] which is about 1.3 times the current annual catch of 550-750,000 t (Table 11-(1)).

The cuttlefish stocks in the region appear, on the contrary, to be nearly fully exploited and no significant increase in catch may be expected other than in the southern region for S. kobiensis and S. recurvirostra. On a conservative basis a range of 120-150,000 t is probably the potential harvest compared with 90-130 000 t current catch (Table 11-(2)).

The octopus stocks have been fully exploited in the northern region but only slightly exploited or even almost untouched in the southern region. It is believed that the potential harvest in the south could be quite large, and probably equivalent to or even more than that in the north. When the longer and more intricate coastline with its numerous islands, and the broader continental shelf area are taken into account, the potential catch could be at least 50-60,000 t.

The total potential harvest of all cephalopod resources from the Northwest Pacific is estimated to be of the order of 950-1,250,000 t which is larger than the current catch by 250-350,000 t or 1.29-1.39 times the current catch.

Management-oriented research should be the major line of enquiry for the northern region specifically for Japanese flying squid and northern oceanic squids. For the southern region, on the other hand, the development-oriented research should be followed including exploratory fishing and investigations of suitable fishing methods especially for catching octopus and pelagic forms of squid.

7.6 Prawns and Shrimps[2/]

The nominal total catch of prawns and shrimps fluctuated greatly in recent years with a range of 300-400,000 t mainly due to the large fluctuations in the annual catches of fleshy prawn and pelagic shrimps (Table 12). The nominal total production may have been considerably underestimated due to the incomplete national statistics from China (mainland provinces) and Korea D.P. Rep. Only catches of fleshy prawn and akiami paste shrimp are reported from the former country and no catch data at all from the latter. The catch of "Other shrimps" along the Chinese coast is believed to be large, judging by the large catches of "Other shrimps", by the Taiwanese and Hong Kong fisheries along the Chinese coast. These comprise various species and yield about 80-90,000 t and 11-17,000 t for these two fisheries respectively. Fishing is mostly by trawl (85 percent) and partly by various small-scale fisheries (15 percent). The catch of "Other shrimps" taken by the Chinese fishery is believed to be at least 100-200,000 t when the large continental shelf there and the considerable domestic consumption of prawn and shrimp products in China are taken into account.

7.6.1 Fleshy prawn, Penaeus chinensis (Osbeck)

Fleshy prawn is mainly distributed in the Yellow Sea, including the Po-Hai Sea and Korea Bay and the biomass of the stock is comparatively large, compared with other large-bodied prawns in the Northwest Pacific. The catch shows a large annual fluctuation and has ranged from 30-40,000 t in recent years. This represents the largest single species catch of prawns in the area (Table 12, Figure 31, Appendix Table 21) and is equivalent to about 2-3 percent of the total demersal fish catch taken from the Yellow Sea and East China Sea (Table 5-(3)).

1/ Japanese flying squid (fully exploited): 300-400,000 t, northern oceanic squid: 250-350,000 t, northern neritic squid (fully exploited): 90-100,000 t, southern neritic squid: 70-100,000 t.

2/ English and scientific names employed in this paper are those defined in the FAO species catalogue Vol.1 Shrimps and prawns of the world (Holthius, 1980)

Table 12

Catch of prawns and shrimps by major species during 1970-81.1/

('000 t)

Species	1970	1975	1976	1977	1978	1979	1980	1981
Fleshy prawn2/	16	40	14	31	42	37	37	41
Kuruma prawn3/	1	7	3	3	6	3	3	4
Pelagic shrimps4/	104	116	126	185	201	108	141	163
Other shrimps 5/	98	142	146	137	161	164	153	150
Total6/	219	305	289	356	410	312	334	358

1/ Catch by Korea D.P. Rep. is not known.
2/ Source: FAO Statistical Yearbooks and Shojima et al., (1982). See Appendix Table 21.
3/ Source: FAO Statistical Yearbooks and Japanese Yearbooks on Fisheries Statistics. See Appendix Table 22.
4/ Source: FAO Statistical Yearbooks. See text for the species involved.
5/ Source: FAO Statistical Yearbooks, catches by China and USSR are not known. See text for the estimate of total other shrimp catch.
6/ Substantially underestimated due to the reasons mentioned above. See Text for the estimate of total catch.

The spawning grounds are located in the shallower water in the Po-Hai Sea and in the northern Yellow Sea along the Korean Peninsula. These appear to be composed of many local groups but for practical purposes, they can be separated into two stocks; the Po-Hai stock with the larger biomass and the West Korean Peninsula stock with the smaller biomass (Shojima et al., 1982, Kim, 1973, Liu et al., 1981). Spawning takes place during April-May. The larvae and juveniles spend 6-7 months in shallower water, and then migrate to the southeastern part of the Yellow Sea for the winter where they stay from mid-November to early April. They copulate during October-November before they migrate to the south. Substantial mixing between the two stocks may take place during the wintering period and they then migrate to the northern coasts the following spring for spawning. The size of adult prawn varies greatly by sex, 20 cm with 90 g body weight for females and 16 cm, with 50 g for males (Deng, 1981). Fecundity is relatively large, about 0.2-1 million eggs (Shojima et al., 1982). The majority of the adult prawns die off at around age-1 after first spawning. The survival of larvae and juveniles during the nursery stage appears to vary greatly and is probably affected by variations in environmental conditions there. It is interesting to see, in this connection, that the Chinese catch in the autumn shows a positive correlation with rainfall during the spawning-nursery period and a negative correlation when the frequency of storms attacked the region during the same period.1/ 2/ The reasons for this phenomena are not known, but these observations are consistent with the large annual fluctuations seen in the commercial catches.

The catch by the Chinese fisheries has been prominent in recent years amounting to 10-40,000 tons annually. Next in importance come the Japanese and Korean Rep. fisheries, both of which flucutuate considerably as referred to above (Figure 31, Appendix Table 21).

1/ Chinese data reported by Men in 1963 and referred to by Shojima et al., (1982).
2/ It is also interesting to see a positive correlation between the catch of Japanese spineless cuttlefish, Sepiella japonica along the central Chinese coast and the magnitude of typhoons which attacked the region (Chen, 1982). The cause and effect may, of course, be quite different from that in the other example quoted above.

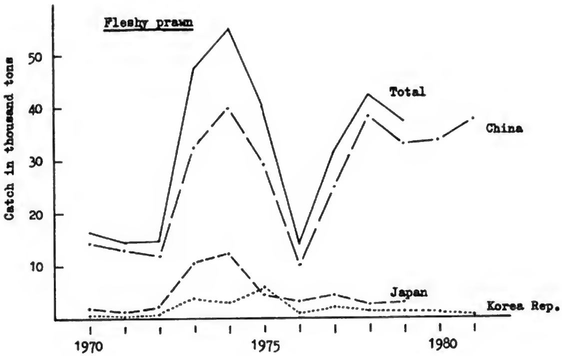

Figure 31. Catch of fleshy prawn by country. See Appendix Table 21 for statistics.

The Chinese catch has been mostly taken in the Po-Hai Sea from September to November by both motorized-sail and mechanized trawlers (Liu et al., 1981). The greater part of the catch is composed of young prawn, 5-7 months old with a body length of 16-18 cm for females and 14-15 cm for males.[1/]

Japanese fishing, on the contrary, depends mainly on the wintering stock, from December to March, on the continental shelf in the southeastern part of the Yellow Sea where the Japanese offshore trawl fishery ("Isei Sokobiki Gyogyo") operates (Shojima et al., 1971). A significant relationship was observed between the location of the fishing grounds for offshore trawlers in winter, and the magnitude of the extension of a branch of Tsushima Warm Current into the Yellow Sea (Shojima et al., 1971). However, this does not appear to have affected annual fluctuations in the offshore catch so much as was observed for the early life stages of the prawn in the Po-Hai Sea. The Japanese catch in offshore waters has been strictly regulated by the Japan-China Fisheries Agreement since 1975 to preserve the spawning stock and this has resulted in a very low level catch for that country since then (Figure 31, Appendix Table 21).

The catch by the Korea Rep. has been taken from both nearshore and offshore waters along the west coast of the Korean Peninsula mostly by trawl, but partly by gillnet and stownet (Kim, 1973, Kim et al., 1977). The catch once attained to 3-6,000 t but has been at a very low level in recent years (Figure 31, Appendix Table 21). The reasons for this decline are not clear.

The catch by Korea D.P. Rep. is not known but it is believed that a substantial catch may have been taken along the country's west coast.

Assessments for the two stocks of fleshy prawn in the region are difficult to make firstly due to the large fluctuations in recruitment and secondly to the lack of detailed information especially of the very large Chinese catch. Catch trends by the three countries are identical until around 1978

1/ Deng et al., (1982) reported that the prawn mate in October and the majority of the males die off after mating, however, details are not known specifically in connection with the offshore migration for wintering as the Korea Rep. data show the equivalent sex ratio between male and female in the wintering ground during January to May (Kim et al., 1977).

(Figure 31). Associated with this are several comments: Chinese and Japanese catches from the same stock may have both reflected changes in stock abundance from year to year. Also they may have affected each other, especially the Chinese catch directly affecting the Japanese catch a few months later in the same year. Since the early 1970's the availability in offshore waters of older prawn aged 9-11 months decreased rapidly (Shojima et al., 1982). This is consistent with an increase in fishing effort by China prior to the offshore fishing season. The mixing of the Po-Hai stock and West Korean Peninsula stock may have been considerable especially during the winter and the decline in the availability of the offshore stock referred to above may have resulted in a significant decrease in the Korean Rep. catch from both stocks. The latter stock, which originally had the smaller biomass, may have declined significantly in recent years. An assessment of the offshore stock by analytical methods indicates that fishing effort has been relatively high since around the mid 1970's (Shojima et al., 1982). Finally the fleshy prawn for both stocks combined appears to have been generally fully and partly overexploited in recent years.

The Chinese catches of the younger prawns remain at a relatively high level with an annual catch of 33-38 000 t (Figure 31, Appendix Table 21). There has been no clear relationship observed between the parent stock and recruitment (Shojima et al., 1982, Ye et al., 1980). It is not clear how a large Chinese catch can continue to be maintained in the future.

7.6.2 Kuruma prawn, *Penaeus japonicus* Bate

Kuruma prawn is a cosmopolitan species distributed widely around the world and is of great commercial value. It prefers warm water with neritic conditions and a sandy bottom. They mostly inhabit the shallower areas in coastal waters where there is a fresh water run-off from the land and where a sea water tidal current prevails.

In the Northwest Pacific this prawn is distributed widely from the northern coast of Honshu, Japan in the north and the northwestern South China Sea through the East China Sea in the south. The stock appears to be composed of numerous small local groups and has never formed a distinct large single unit. The prawns change their habitat from tidal zone to further offshore waters in accordance with their growth and migrate seasonally during their lifespan (about 3 years). The migratory range appears to be fairly narrow, and generally within several tens of kms. A fairly long range displacement of adult prawns has been observed in the Seto Inland Sea, but this may be a special case due to the shallow and highly neritic nature of this Sea (see subsections on Japanese anchovy, cuttlefishes and octopuses). Mixing with neighbouring local groups is probably common, in spite of the fact that they only make short migrations. The spawning grounds of adjacent groups are generally fairly close to each other.

The total catch of kuruma prawn from the Northwest Pacific ranges from 3-7,000 t annually in recent years and of this, the greater part has been taken by Japan and a smaller proportion by the Korea Rep. (Table 12, Figure 32, Appendix Table 22). The catches by China and the Korea D.P. Rep. are not known. Catches are likely to be considerable in the case of China judging from the extensive distribution of the prawn and the level of catches taken by Hong Kong. Catches may be negligibly small in the case of the Korea D.P. Rep. where a cold water scheme prevails.

The total catch is very small, and the smallest single species catch dealt with in this paper. However, the commercial value is extremly high in Japan[1/] and Korea Rep.[2/] Because of this, fishing for kuruma prawn has been carried out intensively in Japan throughout history and has developed recently in the Korea Rep. This species is caught, together with other shrimps and fishes, by various gears such as small setnet, bottom gillnet and small-boat seine/dragnet. The major fishing grounds in Japan are located mostly in the shallower part of the Seto Inland Sea, where about 40-50 percent of the total Japanese catch has been taken. There is also fishing in bays and inlets along the southern and western coasts of Japan. The nature and location of the grounds in the Korea Rep. are almost identical (Pyen, 1974).

The Japanese catch declined drastically during the later half of the 1960's from about 3,000 t to 1,000 t annually (Figure 32, Appendix Table 22). The reasons for this large decline is not known,

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1/ In Japan most of the catch is sold live and the market price is the highest at about $10-45 per kg. For comparison the expensive tunas for "Sashimi" fetches $5-13 and live lobster $10-40 in the major wholesale markets in larger cities in 1981 (Source: Japanese Yearbook on Distribution of Fisheries Products).

2/ A substantial amount of the catch is exported live to Japan (Pyen, 1974).

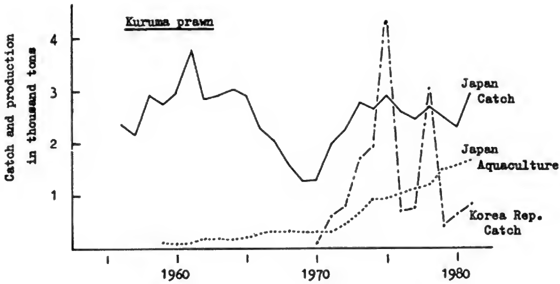

Figure 32. Catch of kuruma prawn by country and aquaculture production in Japan. See Appendix Table 22 for statistics.

but it is generally accepted that a serious decline in stock abundance must have been the major cause. Intensive fishing on kuruma prawn all over the country, during the 1950's and the early 1960's had depleted the abundance of many stocks around Japan. The loss of tidal zones by land reclamation in many bays and inlets, where kuruma prawn had been traditionally harvested, during the same period would also have contributed to the decline.

A national re-stocking programme commenced in Japan in 1966 supported by a remarkable development in artificial breeding, rearing and releasing techniques. The programme has been expanded to a nation-wide level by central and almost all local governments in central to southern Japan. The total number of juvenile prawns released by the re-stocking project has been increased within 15 years, from about 10-20 million per year at the initial stage to about 600 million in 1980. The commercial catch in many fishing grounds, especially in the Seto Inland Sea, has been recovering significantly since the early 1970's and has continued to grow in recent years (Cowan, 1981). However, no assessment has been made of the effect of the re-stocking programme.

A large development in aquaculture in Japan is another particular aspect of the Japanese fishery, and total production is approaching that of the commercial catch in recent years (Figure 32, Appendix Table 21). However, it should be noted that the commercial catch in recent years may include the prawns that have been artificially released. For this reason, an assessment of the re-stocking programme is urgently needed.

The catch by the Korea Rep. increased rapidly since the early 1970's and has shown large annual fluctuations since then. The reason for these fluctuations is not clear, however, the overall catch trend seems to have been rapidly declining since around 1975. The stocks may have been fully exploited or even overexploited on many local grounds in the Korea Rep.

Kuruma prawn resources are minor in terms of quantity and significantly greater catches are not expected in the future. An explicit and global assessment of the prawn stocks and of the re-stocking programme in Japan is urgently needed. It will be interesting, in this connection, to see what happens to the Korea Rep. catch in the immediate future since no re-stocking programme has been implemented by that country.

7.6.3 Pelagic shrimps, Sergestidae

Among a number of pelagic shrimp species,[1/] a few species of the family Sergestidae are abundantly distributed in the Northwest Pacific and have been commercially harvested. A brief review of these shrimps is made below.

1/ A global review of pelagic shrimps in the world ocean was well documented by Omori (1974).

(1) Paste shrimps, Acetes spp.[1/]

Although only a single species is reported in the nominal statistics, there appear to be at least five species of the genus Acetes that are commercially utilized (Omori, 1975). These are:[2/] northern mauxia shrimp, Acetes chinensis Hansen, (SJ-WJ-YS-ES), akiami paste shrimp, A. japonicus Kishinouye, (CJ-YS-ES-SC), Tsivakihini paste shrimp, A. erythraeus Nobili, (ES-SC), southern mauxia shrimp, A. serrulatus (Kroyer), (ES-SC) and Taiwan mauxia shrimp, A. intermedius Omori, (ES-SC).

The northern mauxia shrimp, A. chinensis is prominent among these species and has been caught in large quantities along the northern Chinese coast and the western Korean Peninsula. Akiami paste shrimp, A. japonicus has the second largest biomass and has been traditionally caught in several local waters around Japan. The other three species, A. erythraeus. A. serrulatus and A. intermedius appear to be in the minority and are distributed in the southern part of the area. They have been caught along the southern Chinese coast including the waters around Taiwan, Province of China and Hong Kong.

Acetes is a typical pelagic shrimp and prefers a highly neritic environment influenced by a considerable discharge of fresh water from the land. They also prefer muddy bottoms associated with extensive shallow water areas with strong tidal currents and sheltered from the open sea. They commonly inhabit bays and inlets including estuaries and brackish waters. They grow to about 15-20 mm body length within a few months[3/] and die off soon after first spawning with a lifespan of 10-11 months.[4/] They usually inhabit waters shallower than 50 m deep and migrate diurnally upwards at night and downwards during the day. Their tendency to aggregate is strong, especially at night in the surface layer of the sea.

The nominal total catch of paste shrimps in the Northwest Pacific is considerable, amounting to about 100-200,000 t annually in recent years (Table 12). Most of this is reported to have been taken by China (about 90-95 percent of the total catch) and the remainder by the Korea Rep. (5-10 percent). Although Japan, Hong Kong and Taiwan, Province of China also have substantial harvests of paste shrimps, their catches have not been separated in the nominal statistics from the category "Other shrimps". The nominal catches reported as akiami paste shrimp, A. japonicus, that are reported from China and the Korea Rep. are believed to be a mixture of several species. These are mostly comprised of A. chinensis and partly of A. japonicus along the northern coast of China to the west coast of the Korean Peninsula and a mixture of A. chinensis, A. erythraeus, A. serrulatus and A. intermedius along the central, to southern coast of China (Omori, 1975).

The Japanese catch of paste shrimp, which have not been separated in the nominal statistics but are included under "Other shrimps" is estimated to be 1-2,000 t annually and is comprised mostly of akiami paste shrimp, A. japonicus (Ibid.). The fishing grounds in Japan have been limited to four isolated local places which is a peculiar characteristic of this shrimp around Japan. The fisheries have a long history, for more than 100 years, and during this period fishing has been confined to four grounds. These are: (1) Toyama Bay along the central Japan Sea coast, (2) the eastern and (3) the western part of the Seto Inland Sea and (4) the Ariake Sea in the western Kyushu (Ikematsu, 1963, Yasuda et al., 1953, Omori, 1975).

Shrimps are caught mostly by stownet in China and Korea Rep., by bagnet and pushnet in Hong Kong and Taiwan, Province of China, and by bagnet, boat-seine and pushnet in Japan. The fishing seasons are usually twice a year, in March-July and in September-November.

The catches of any one species of paste shrimps fluctuate greatly both seasonally and annually. These fluctuations seem to have been caused mainly by natural factors, firstly due to fluctuations in recruitment resulting from variations in early survival rate and secondly due to changes in availability associated with particular oceanographic conditions and shoaling behaviour. For example, the density of A. japonicus on fishing grounds in Japan has been recorded as high as 30,000 individuals per cubic metre under favourable conditions compared with extremely low densities on

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1/ A global review of Acetes spp. in the world is well documented by Omori (1975).
2/ See footnote in the subsection 7.5.1 (3) on Neritic Squids for the abbreviation of localities.
3/ A. chinensis attains the largest body size at about 25-35 mm body length.
4/ A. japonicus is composed of summer and winter broods with a lifespan of 1-3 months for the former and 10-11 months for the latter (Yasuda et al., 1953, Omori, 1975).

other occasions (Omori, 1975). Precise assessments of the shrimp stocks are difficult to make mainly due to their complicated ecological features. However, fishing mortality has probably not accounted for changes in abundance and there have been neither long-term nor short-term relationships observed between catch and recruitment. It appears that A. chinensis in the Yellow Sea and northern East China Sea are nearly fully exploited while other species in other regions may be moderately exploited. However, it is doubtful that greater catches for these species would be achieved by an increase in fishing effort as the overall availability of shrimps may be limited by natural conditions. It is considered that the current total annual catch of about 100-200,000 t may be sustainable and near the maximum level. However, the managerial consideration may not be required for the time being for these particular resources.

The author proposes that attention should be drawn to the role of shrimps as food for fish especially coastal pelagic fish; attention should also be given to the effects of the incidental catches of larvae and juveniles of other commercially valuable crustacea and fish species that are taken by paste shrimp fishing gears, especially by stownet. It is believed that the stownet catches large quantities of post-larvae and juveniles of penaeids and pelagic/demersal fish. The fishing grounds of paste shrimps generally overlap the nursery grounds of other species, and further research is strongly recommended.

(2) Sakura shrimp, Sergestes lucens Hansen

Sakura shrimp is notable for its very limited distribution and long history of exploitation. This species is one of the upper-mesopelagic species that is so far found only in Suruga Bay, central Pacific coast of Japan and has been commercially exploited there for about 100 years. In recent years[1/] the annual catch has been 3-8,000 t (Omori, 1973).

This is an offshore species of shrimp that lives pelagically in water 200-500 m deep more or less independently of the bottom. In fact, neither wide tidal zones nor continental shelves are developed in the Bay and bottoms are mostly sandy or gravel. It grows fairly rapidly attaining 20 mm body length within 3-4 months, and the length range of the commercial catch is about 20-40 mm. They mature at the age of around 9-10 months and die off soon after first spawning at around 10-11 months.

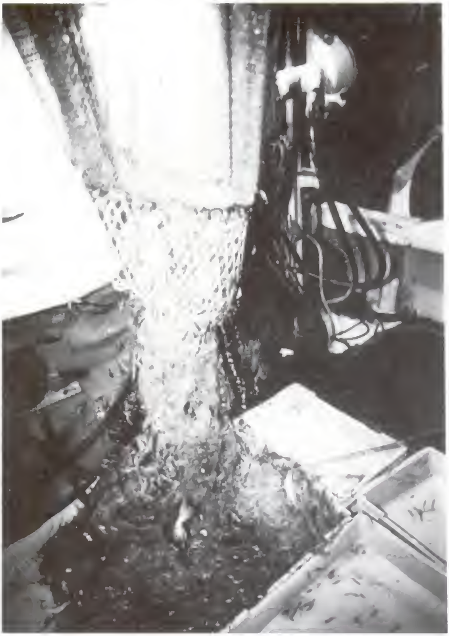
Sakura shrimp are caught by boat-seine at night when they migrate to within 100 m of the surface. Fishing is prohibited during June to September to protect them when spawning during summer. Fishing is therefore twice a year, in spring and autumn. The total number of seine-nets employed is restricted to 60 and these are licensed to the three selected cooperatives along the coast of the Bay. The catch fetches a relatively high price in Japan of about U.S. $0.5-1.0 per kg in 1969 at the wholesale market depending on the size of the catch (Omori, 1973). This was equivalent to the price of Japanese Jack mackerel, and skipjack tuna and 2-4 times the price of anchovies and sardine in the same year. The resources seem to have been fairly stable and to have been nearly fully exploited.

Further research on the population dynamics and other ecological features of the sakura shrimp, including the causes of variations in year class strength are needed in future. Due to its isolated distribution and presumably less complex relationship with other animals this shrimp may be the easiest of the pelagic shrimps to study. Such studies should contribute greatly to the overall understanding of the biology of pelagic shrimps.

7.6.4 Other prawns and shrimps

A great number of prawns and shrimps have been commercially harvested in the Northwest Pacific, although most of them are distributed in the southern region of the area, from central Japan to the northwestern South China Sea through the Yellow Sea and East China Sea. The ecological features of the various resources and their state of exploitation differ greatly from north to south.

1/ The catch has not been separated in the nominal catch statistics in Japan but is included in the catch of "Other shrimps".



PHOTOGRAPH 11. Catch of sakura shrimp by night fishing by a boat seine of the Yuki Fisheries Cooperative, Suruga Bay, central Pacific coast, Shizuoka prefecture. Fishing is granted exclusively to the three selected Fisheries Cooperatives bordering the Bay. The number of vessels is strictly limited to 120 (60 nets by two-boat boat-seine) and the vessel size is also limited to within 4-6 GRT. The Japanese name of the shrimp, "Sakura" refers to its beautiful light pink colour like "Sakura", (cherry blossom).

Photograph taken by K. Soehata (Yamaha Motor Co. Ltd., 1983).

(a) Northern region

The major species in the northern region are limited to only a few species although the biomass of each of these is relatively large compared with those in the southern region. The humpy shrimp, Pandalus goniurus Stimpson which is found in the Anadyrskiy Bay along the northeastern Siberian coast and the northern shrimp, P. borealis Krøyer which is found in the Okhotsk Sea[1/] are the two principal species in the region. Other and minor species in the region are: hokkai shrimp, P. kessleri Czerniavsky, morotoge shrimp, Pandalopsis japonica Balss, "mitsukuri shrimp",[2/] P. mitsukurii Rathbum and "higoromo shrimp",[2/] P. coccinata Urita.

The two major species were once exploited on a large scale by directed fishing. For example, humpy shrimp, P. goniurus was intensively exploited in the Anadyrskiy Bay by both the USSR and Japanese trawl fisheries during the period 1967-71 with about 4-14,000 t annually. However, the catch decreased drastically after 1972 and the Japanese fishery ceased trawl fishing soon and has been completely prohibited since 1977 in connection with the extension of the USSR jurisdiction. The state of the USSR fishery in recent years is not known.

The sequence of events for the northern shrimp, P. borealis stock in the Okhotsk Sea is similar to that which occurred a few years later. Since around 1970 there was a large scale directed fishing, and the annual catch by the Japanese trawl fishery during the period 1970-75 ranged from about 3-5,000 t. The catch by the USSR fishery during that period is not known but was presumably quite large. The Japanese catch and cpue declined sharply after 1974 and the Japanese fishery has ceased fishing completely since 1977 when the USSR jurisdiction was extended. The state of exploitation of the USSR fishery in recent years is not known.

There is little doubt that these stocks declined seriously during the 1970's, and that this was mainly due to overexploitation. These shrimps[3/] change sex at around the midpoint of their life. They mature at around age-1 as males, and sex reversal takes place at ages -2.5 to 3. All shrimps older than age-3 are mature females. They spawn every year until the end of their lifespan at ages -4 to 5. The intensive exploitation of such a stock, would result in a decline in mature males in the next generation and accordingly a decline in mature females 2 years later. This could result in a rapid decline in the stock within only a few years. Size composition data for the Japanese catch suggests such a process to have been employed in the decline of the above mentioned two stocks.

Another aspect of interest is that shrimps are one of the important food items of demersal fish, and especially for pollack, cod and flatfish and considerable quantities of shrimps are eaten by these fishes. Furthermore, the rapid decline in shrimp abundance took place at the same time as the rapid increase in the catches of Alaska pollack in the Northwest Pacific (Figure 8, Appendix Table 3). If the abundance of Alaska pollack really did increase during this period as was discussed in the subsection 7.2.1 in this paper, they would have had a significant predatory impact on the shrimps. Further research, and studies of both fishing and natural mortality rates, in association with the particular life histories of these shrimps and their inter-specific relationships with predators are highly desirable in the future.

The other species in the northern region are Pandalus kessleri, Pandalopsis japonica, P. mitsukurii and P. coccinata. These supposedly consist of many small local stocks, including local groups of P. borealis, and have never been exposed to intensive fishing mostly due to their limited availability. These stocks appear to have remained at favourable levels throughout the years though their potential yields are far below those of the two major stocks in the region.

(b) Southern region

A number of prawns and shrimps have been commercially utilized in the region, south of central Japan. Comprehensive information on the commercially important species is not available for those around Japan where about 15 species are commonly found on the market. With better identification of species in the East China Sea to northwestern South China Sea it is likely that the total number of species of commercial value would be found to exceed twenty. However, the biomass of each species is relatively small.

1/ P. borealis are also distributed in the waters along the Kuril Islands and the northern Japanese coast including the Japan Sea where small but continuous catches have been taken as bycatches.

2/ Japanese names, standardized FAO names have not been established for these species.

3/ The life history of P. goniurus is unknown, but is believed to resemble that of P. borealis as both species are taxonomically close.

The major species found on the Japanese market are: (1) the giant tiger prawn, Penaeus monodon Fabricius, (2) the green tiger prawn, P. semisulcatus De Haan, (3) the western king prawn, P. latisulcatus Kishinouye, (4) the shiba shrimp, Metapenaeus joyneri (Miers), (5) the speckled shrimp, M. monoceros (Fabricius), (6) the tora velvet shrimp, Metapenaeopsis acclivis (Rathbum), (7) the whiskered velvet shrimp, M. barbata (De Haan), (8) the humpback shrimp, M. lamellata (De Haan), (9) the moyebi shrimp Metapenaeus moyebi (Kishinouye), (10) the southern rough shrimp, Trachypenaeus curvirostris (Stimpson), (11) the jack-knife shrimp, Haliporoides sibogae (De Man) and (12) the botan shrimp, Pandalus nipponensis Yokoya, many of which are widely distributed in warm waters in the Indo-Pacific region.

The total catch of "Other shrimps" by Japan, which is composed mostly of these species, has been fairly stable at about 40-45,000 t annually in recent years. They are caught by various gears, including small-scale dragnet which accounts for about 50 percent of the total catch, as well as by trawl, boat-seine, gillnet, setnet and trap. The shrimp catch from the narrow Seto Inland Sea accounts for 45-55 percent of the total Japanese shrimp catch1/ and is composed mostly of green tiger prawn, shiba shrimp, speckled shrimp, tora velvet shrimp, whiskered velvet shrimp, moyebi shrimp and southern rough shrimp (Yasuda, 1956, Yasuda et al., 1957), and is ranked as the 7th largest catch in the Sea fish catch (Tatara, 1981).

The catch by Korea Rep. has also remained at a fairly stable level with about 10-13,000 t annually in recent years. The species composition of the catch is not known but is believed to be almost the same, including the northern species, to that of Japan.

The catches by Hong Kong and Taiwan, Province of China are fairly stable too with about 10,000 and 80,000 t annually respectively. These are taken mostly by trawl as a bycatch. The species composition of these catches is not known, but the major Indo-Pacific species have been confirmed in the Hong Kong catch, i.e. giant tiger prawn, green tiger prawn, western king prawn, shiba shrimp, speckled shrimp, whiskered velvet shrimp, moyebi shrimp and southern rough shrimp. In addition, several tropical species are probably exploited by these fisheries.

Information on the catch by China (mainland provinces) is completely lacking. It is estimated, however, that at least 100-200,000 t of the category "Other Shrimps" must have been taken along the Chinese coast if one takes account of the catch by Hong Kong and the Taiwan fisheries (about 90,000 t altogether), as well as the long Chinese coastline and the presumably huge domestic consumption in China. The stocks are believed to have been fully or even overexploited as trawl fishing by China, as well as Taiwan Province and Hong Kong, has been quite intense.

7.6.5 Summary for prawns and shrimps

From the considerations above, it has become apparent that the prawn and shrimp stocks in the Northwest Pacific have been generally fully and partly overexploited.

Overexploited stocks include the stocks of humpy shrimp in Anadyrskiy Bay and the northern shrimp in the Okhotsk Sea. Part of the fleshy shrimp stock in the Yellow Sea has probably also been overexploited, particularly the West Korean Peninsula stock and part of the Po-Hai Sea stock. More careful research, especially for management purposes, is required on these stocks in future. Strict management measures have already been enforced by the Japan-USSR Fisheries Convention for the first two stocks and the China-Japan Fisheries Agreement for the latter. Careful monitoring of the state of these stocks is required in the immediate future.

Other stocks around Japan and the Korean Peninsula appear to have been stable at a certain level with the exception of the kuruma prawn stock around the Korean Peninsula. Exploitation of these stocks generally does not appear to have been so high due to a relatively low availability on the one hand and to a strict regulation in Japanese coastal waters on the other.2/ Monitoring and further biological research may therefore be the major lines to be followed in the immediate future. Interspecific relationships with fish stocks especially in relation to predatory loss, should also be intensively studied in the future, as this is important for both the shrimp and the fish stocks.

Stocks of the other prawns and shrimps further south, in the Yellow Sea to the northwestern South China Sea should also be urgently studied as information for stock assessment purposes is almost completely lacking.

1/ Source: Japanese Yearbooks of Fisheries Statistics.
2/ The situation in Korea Rep. and Korea D.P. Rep. is not clear.

Apart from uncertainties, no greater catch can be expected for this species group in the future. The current annual catch of 400-600,000 t[1] is therefore probably the maximum potential yield of the category "Other prawns/shrimps" in the Northwest Pacific.

Aquaculture[2] may lead to a certain quantity of commercially valuable production, but this is probably more important for socio-economic reasons than as a means of utilizing a natural resource. It should be emphasized, in this regard, that an assessment of the kuruma prawn re-stocking project in Japan is urgently needed.

Another interesting topic is the recent development of Euphausid crustacea fishing along the central, to northern Pacific coast of Japan (Odate, K., 1979). Fishing on "Tsunonashi Euphausia",[3] Euphausia pacifica Hansen has been one of the traditional small-scale fisheries in the region by scoopnet. However, fishermen initiated intensive fishing about 1953 due to a strong demand for the landings as a feeding material for the rearing of red seabream and trout. The catch has increased steadily from the 100-200 t level at the initial stage to 20-40,000 t in the late 1970's. Fishing for direct human consumption has been negligible so far, however, it may be worthwhile as the unconventional resources are utilized for fisheries purposes. They are caught by the traditional scoopnet method at night and the length composition of the catch ranges about 16-22 mm. Catches fluctuate considerably due to fluctuations in availability probably caused by changes in the oceanographic conditions on the fishing grounds. However, the biomass appears to be enormous (Odate, T., 1979) and the species has been well known as an important food item for Pacific saury, Japanese chub mackerel, Alaska pollack and other fish including squids as was discussed in the previous sections. Further research and continuous monitoring of the fishery are highly desirable in the future, both in connection with the biology of the species as well as with the population dynamics of the pelagic fish species which feed intensively on Euphausia.

8. DISCUSSION

8.1 Current Catch and Distinctive Features

Recent total catches broken down by world ocean and FAO fishing areas are given in Table 13. The catch from the Northwest Pacific has been prominent among the world's fishing areas accounting for about 29-30 percent of the total world catch and about 52-53 percent of the total catch from the entire Pacific Ocean. The second largest catch has been taken from the Northeast Atlantic Ocean but this is about one half that from the Northwest Pacific. It is notable that the large catch from the Northwest Pacific area has been mainly supported by a few major species, namely, Alaska pollack, Japanese sardine, Japanese chub mackerel, Japanese anchovy, Pacific saury, Japanese flying squid and various oceanic squids for which the combined catch has accounted for about 45 percent of the Northwest Pacific total. The nature resembles very much that of the Northeast Atlantic from where the second largest catch in the world has been taken, is chiefly supported by Atlantic herring, Atlantic cod, sprat and Atlantic mackerel.

In the Northwest Pacific the catch has increased by 4-6 percent annually in recent years while in the other world oceans recent catches have been fairly stable. The very large increase in the catches have been supported by a few species, and particularly by Alaska pollack and Japanese chub mackerel and since the early 1970's by Japanese sardine. The very largest catches in recent years may have been associated with transitional phases in the pelagic fish community, and this will be discussed further in a later part of this section.

An index of the overall density of resources, and the productivity of the area can be measured approximately by the catch per unit shelf area.[4] Productivity in the Northwest Pacific shows the second highest value among the world areas with 7.03 t/km^2 (Table 13). The highest value comes from the Southeast Pacific with 17.68 t/km^2. However, this is exceptional and is associated with an area where almost no demersal resources exist due to the very narrow and steep continental shelf, but where there are numerous coastal pelagic resources such as Peruvian anchovy, sardine and Jack mackerel supported by highly favourable oceanographic conditions.

1/ Nominal catch of 300-400,000 t plus estimated additional catches taken by China and Korea D.P. Rep., about 100-200,000 t.

2/ Kuruma prawn in Japan and Korea Rep., fleshy prawn in China and Korea Rep. and tiger prawn in China (mainland and Taiwan Provinces).

3/ "Tsnonashi Euphausia": antenna-less Euphausia in Japanese.

4/ Continental shelf area shallower than 200 m. The measure does not represent absolute density of resources or productivities of the waters as some pelagic stocks are not entirely dependent on the shelf area but on particular oceanographic conditions in surface to mid-water depths.

Table 13

Recent total catch[1] and the catch per unit area of continental shelf[2] by world ocean and FAO fishing areas.

Ocean and Area (FAO notation no.)		Recent catch ('000 t) 1980	1981	1982	Continental shelf area[3] ('000 km²)	Catch per[4] shelf area (t/km²)
Pacific Ocean						
Northwest	(61)	18,759	19,486	20,585	2,770	7.03
Western Central	(71)	5,809	6,109	5,939	3,120	1.96
Southwest	(81)	380	396	403	1,340	0.30
Northeast	(67)	1,961	2,356	2,185	2,100	1.12
Eastern Central	(77)	2,422	2,607	2,370	450	5.79
Southeast	(87)	6,228	6,843	7,841	387	17.68
(Sub-total)		(35,559)	(37,797)	(39,323)	(10,167)	(3.72)
Atlantic Ocean						
Northwest	(21)	2,867	2,825	2,824	1,260	2.24
Western Central	(31)	1,791	1,898	2,131	1,370	1.39
Southwest	(41)	1,273	1,253	1,541	1,950	0.64
Northeast	(27)	11,798	11,648	10,719	3,155	3.69
Eastern Central	(34)	3,440	3,218	3,196	480	6.70
Southeast	(47)	2,171	2,387	2,372	410	5.82
Mediterranean, Black Sea	(37)	1,654	1,703	1,881	511	3.33
(Sub-total)		(24,994)	(24,932)	(24,664)	(9,136)	(2.73)
Indian Ocean						
Western	(51)	2,091	2,007	2,022	790	2.54
Eastern	(57)	1,459	1,513	1,540	2,210	0.68
(Sub-total)		(3,550)	(3,520)	(3,562)	(3,000)	(1.17)
Antarctic Ocean (48,58,88)		592	569	648	-	-
World total		64,695	66,818	68,197	22,303	2.97[5]

1/ Source: FAO Statistical Yearbooks.
2/ Shallower than 200 m.
3/ Mostly from Gulland (1971).
4/ Catch in 1981.
5/ Excluding the catch from the Antarctic Ocean.

By comparison the Northeast Atlantic, which provides the second largest production with 11-12 million tons annually, is ranked as 6th in catch per shelf area with 3.69 t/km^2 (Table 13). This area benefits from a highly favourable environment for both the demersal and pelagic resources due to the large continental shelf area (3,155,000 km^2) and favourable oceanographic conditions associated with both cold and warm currents. The ratio of demersal to pelagic fish production is nearly 50:50 for both in the Northeast Atlantic (Gulland, 1971, FAO, 1983) and also the Northwest Pacific.

The other areas in the world with a fairly high catch per unit shelf area are all characterized by a relatively large pelagic fish catch. By contrast, the areas where the catch per unit shelf area is low are characterized by a large continental shelf area and a relatively small pelagic fish catch. The Mediterranean and Black Sea appear to be exceptions probably due to their particular environmental conditions. The table below summarises these points.

	Catch per shelf area (t/km^2)	Component of pelagic fish catch (%)	Estimated* potential (million t)
Southeast Pacific	17.7	80-90	12-14
Northwest Pacific	7.0	40-45**	20-22***
Eastern-Central Atlantic	6.7	65-70	8-12
Southeast Atlantic	5.8	62-65	4-5
Eastern-Central Pacific	5.8	78-80	10-12
Northeast Atlantic	3.7	50-55	14-16
Mediterranean, Black Sea	3.3	59-68	1.5
Western-Central Pacific	2.0	30-40	?
Northeast Pacific	1.1	4-7	2.5-3.3
Southwest Atlantic	0.6	35-40	3.1-3.8

* After Gulland (1971) and FAO (1983), several figures were modified by the author.
** Excluded shellfishes.
*** Estimated by the author, see Table 14.

The table shows that the potential yields for some of the areas with relatively large catches per unit shelf area are considerably smaller than those for the Northwest Pacific and Northeast Atlantic.[1/] Also it can be noted that the total catches in many areas have fluctuated greatly, especially in the Southeast Pacific, due to large changes in the abundance of a single or of a few major pelagic fish stocks.

8.2 Relationship with the Environment

There are two large continental shelves in the Northwest Pacific. One in the Okhotsk Sea and the other in the Yellow Sea to the northwestern South China Sea (Table 1, Figure 1). There are also two important currents influencing oceanographic conditions in the area. These are (1) the East Kamchatka-Oyashio from the north which is cold but productive and (2) the Kuroshio with a warm

1/ The potential yield for the Southeast Pacific is large with 12-14 million tons. However, this has been estimated on the assumption that the Peruvian anchovy has a potential yield of 9-11 million tons equivalent to the level in its prosperous period during the 1960's, rather than on the current catch which has only been about 1-2 million tons. The potential in a long-term sense, could be substantially smaller if the "Great Catch Period" is considered to be a temporary phenomenon at the upper limit of a large fluctuation in stock abundance. The same point will be made with reference to the Japanese sardine in the Northwest Pacific later in this section.

and subtropical nature from the south (Figure 2). These two current systems have provided the seas and regions in the area with particular characteristics and productivities. For example, the Okhotsk Sea and the northern Pacific coast of Japan on the one hand have a boreal nature and high primary productivity (Table 2). The central Japanese coast (along both the Pacific and Japan Sea sides) to the East China Sea experiences subtropical and warm water conditions with a fairly high level of primary productivity on the other (Table 2). The divergence of the two current systems has also given rise to special oceanographic conditions off the northern Pacific coast of Japan and in the eastern and western parts of the Japan Sea and these have favoured biological production and the fisheries in these regions.

The geographic distribution and abundance of resources in the area differ greatly by species and locality. For example, the Okhotsk Sea is characterizd by a large production of Alaska pollack and yellowfin sole.1/ The Okhotsk Sea and the northern Japan area, including the high seas in the northern North Pacific, are also large producers of salmons.

The waters along southern and western Japan to the eastern East China Sea contain many pelagic stocks in highly favourable environments for spawning. For example, these include Japanese sardine, Japanese chub mackerel, Japanese Jack mackerel, Pacific saury, Japanese yellowtail, northern bluefin tuna and Japanese flying squid all depend on the region for spawning and recruitment and have been successfully fished along the entire coast of Japan.

In the offshore waters along the Pacific coast of Japan highly migratory oceanic fish such as skipjack and the larger tunas are intensively exploited being mostly supported by the inflow of the Kuroshio and the existence of abundant food animals. A typical phenomenon is the regular feeding migration and large catches of skipjack tuna. The oceanographic complexity formed by the convergence of the Kuroshio and the Oyashio has also contributed to an enhancement of the availability of pelagic fish resources such as saury, mackerel, squids and skipjack tuna and to the high production of the fisheries on them.

The littoral zone of the Kuroshio and Tsushima Warm Current also provide extremely favourable conditions (Table 2) for coastal pelagic and demersal species such as Japanese anchovy, sandlances, flatfishes, seabreams, various ground fishes, neritic squids and cuttlefishes, octopuses, prawns and shrimps. About 1.1-1.6 million tons of these species2/ are estimated to have been caught, mostly by Japan and partly by the Korea Rep. from relatively narrow continental shelf areas (Table 1, Figure 1).

Details of the resources that inhabit the northwestern Japan Sea are not clear due to the lack of information for the Korea D.P. Rep. and the USSR along the Primorskiy coasts (Table 5-(3)). It is believed, however, that the situation is probably similar to that along the Japanese and Korean Rep. coasts in the Japan Sea comprised both of warm and cold water type species. If sardine stocks in the Japan Sea grow like those during the "Great Catch Period" in the 1930's the situation would greatly change, since the sardine catches of around 1 million tons would become overwhelming.

Apart from the spawning stocks of the major pelagic species mentioned above, the Yellow Sea and East China Sea are also highly productive in demersal resources. Although the nominal catch is nearly equivalent to that of pelagic fish with about 1.5 million tons4/ (Table 5-(3)), the actual total catch of demersal fish is believed to be far above this figure. Allowing for the Chinese and Korean D.P. Rep. incomplete statistics, the catches may be around 2.5-3.0 million tons or more, which is nearly equivalent to that from the Okhotsk Sea, and is composed of various species as discussed previously (cf. Appendix Table 10-(2), 10-(3)). It is notable that the Yellow Sea and the northern East China Sea provide a very favourable environment for boreal to temperate pelagic and demersal stocks. For example, Pacific herring, Japanese spineless cuttlefish, fleshy prawn and several pelagic shrimps.

1/ Pacific herring may have to be added as one of the representatives if the recent decline in stock abundance is considered to be temporary in a long-term sense.

2/ Japanese anchovy: 350-400 ('000 t), "Shirasu": 50-60, sandlances: 100-200, demersal fish: 300-440, neritic squids3/: 100-150, cuttlefishes: 50-70, prawn and shrimps: 100-160 (Total: 1,100-1,550).

3/ Excluding Japanese flying squid.

4/ Includes the Taiwanese catch.

Details are not known about the resources in the northwestern South China Sea along the Chinese coast. It is believed however that demersal fish stocks are important followed by a substantial biomass of tropical coastal pelagic fish such as mackerels, scads and anchovies.

The waters around Japan are particularly productive for both pelagic (about 5.0-5.5 million t) and demersal (1.2-1.5 million t) fish, and account for about 17-28 percent of the total production from the entire Northwest Pacific.

Taken as a whole the production from the Northwest Pacific is complex. There are several different species-specific and geographic-specific levels of production, just as in the second highest productive area, the Northeast Atlantic. This suggests that both areas benefit from suitable environmental conditions[1/] for a well balanced and high level of production from the sea.

8.3 Changes in Stock Abundance and Dominancy

Many of the major stocks in the Northwest Pacific have experienced large changes in stock abundance. The stocks which have probably been depleted by overexploitation are: several salmons[2/] (pink, chum, sockeye and chinook salmons), Pacific ocean perch and rockfishes in the northern region, yellowfin sole in the Okhotsk Sea, humpy shrimp in Anadyrskiy Bay, northern shrimp in the Okhotsk Sea, kuruma prawn and red seabream in the waters around Japan, and many demersal fish stocks in the Yellow Sea and East China Sea. Several salmon stocks and kuruma prawn have shown a recovery in stock abundance in recent years mostly due to restocking projects. However the other depleted stocks have not yet shown a clear indication of their recovery.

Stocks which seem to have changed due to natural causes are: Pacific herring, Japanese sardine, Japanese chub mackerel and Japanese Jack mackerel. A particular phenomenon is the change in the availability of Japanese yellowtail even though the biomass of the stock appears to have remained much the same.

Stocks which have increased due to natural causes are filefish in the southern regions, probably Alaska pollack in the Okhotsk Sea and largehead hairtail in the East China Sea.

Stocks which have not shown a substantial change or which have fluctuated at about a certain level of abundance are: Pacific cod, Atka mackerel, sandlances, several demersal fish around Japan (except rockfishes, red seabream, and kuruma prawn), Japanese anchovy, Japanese Spanish mackerel, skipjack tuna, cephalopods (except Japanese flying squid), fleshy prawn and pelagic shrimps. It is notable that Japanese anchovy is the only species which has been neither seriously depleted nor remarkably dominant among the coastal pelagic fish stocks around Japan.

The cause and the problems which might have been involved in each of the above mentioned changes in stock abundance have already been discussed in detail in the earlier sections of this paper. The changes are particularly large for the coastal pelagic fish stocks. By contrast, the demersal fish stocks generally appear to be relatively constant but fragile against heavy fishing. Typical examples are the rockfishes in the northern region and the demersal fish in the Yellow Sea and East China Sea. The management of the resources is therefore particularly important for demersal stocks. Changes in the dominant species in the demersal fish community hardly occurs and extraordinarily large catches, such as occur in the case of mackerels or sardine in the pelagic fish community cannot be expected. However, species which are both demersal and pelagic in habit may show large changes in stock abundance and overwhelm other demersal species or even pelagic fish species. The author is inclined to adopt such a hypothesis to account for the changes in Alaska pollack in the Okhotsk Sea, filefish and largehead hairtail in the East China Sea.[3/]

The change in stock abundance and, therefore the change in relative importance of different coastal pelagic fish species is outstanding as discussed previously. These changes are due to natural causes, but no clear explanations for these phenomena or a reasonable hypothesis to account for them, have yet been given. Requirements for future research will be discussed in the following

1/ The man-made condition, i.e. the control of fishing mortality through the management of fisheries is also very important at the same time especially for demersal fish stocks which will be discussed in the next sub-section.

2/ The cause of the decline may also be attributable to deterioration in their spawning grounds for both artificial and natural reasons.

3/ The counter-phenomena of these are the decline in herring and yellowfin sole for the first and a general decline of the other demersal stocks in the latter.

section. Apart from the processes involved in these changes, it should be noted that total production from the complexity of the major pelagic fish stocks around Japan had been fairly stable at a very high level for more than 40 years (except for the World War II period) until the early 1970's (Figure 29, Appendix Table 19). This may be associated firstly with the high level of production of pelagic fish, and secondly with the level of primary production and the favourable oceanographic conditions. The recent extremely large catches are mostly due to sardine, and are unlikely to be sustained for long in future. The author assumes that this may be one of the unstable periods of the pelagic fish community, similar to the "Great Catch Period" of the 1930's and will probably be followed by a decline.

8.4 Estimated Potential and State of Exploitation

As was discussed in each of the species-group sections, many of the major stocks in the Northwest Pacific have already been fully exploited and several stocks have been overexploited. A significant increase in catch in the future cannot be expected therefore. The potential harvest in the Northwest Pacific has been estimated for each species group, and values are given in Table 14.

Table 14

Estimated potential yield by species group and a comparison with current catches in the Northwest Pacific.

('000 t)

Species group	Potential yield	Current catch	Possible increase
Salmon	300-350	200-250	100
Demersal fish	6,500-7,000	5,700-6,200 1/	100-200
Coastal pelagic fish	5,800-6,500	5,500-6,200 2/	100-200 3/
Tunas and billfishes	280-380	250-350 4/	20-30 5/
Other fish	?	3,800	?
Cephalopods	950-1,250	700-900	250-350
Prawn and shrimps	400-600	300-350 6/	0
Other crustacea	?	250	?
Shellfish	?	1,400	?
Others	?	100	?
Total	19,780-21,630 7/	18,200-19,800 8/	570-880 9/

1/ Nominal statistics, actual catch is several hundreds greater than the nominal figure, probably 6,300-6,800.

2/ Nominal statistics, actual catch is several hundreds greater than the nominal figure, probably 5,700-6,300.

3/ Refers to only the coastal pelagic stocks in the southern region. See text for details.

4/ Includes estimated catch of smaller tunas.

5/ Refers to only the smaller tunas such as bullet, frigate and eastern little tunas.

6/ Nominal statistics. The actual catch is considerably greater than the nominal figure, around 400-600.

7/ Questionable species groups are assumed to be the same as current catches.

8/ Nominal statistics, actual catch far greater than the nominal figure, probably around 19,000-20,800.

9/ No increase is assumed for questionable species groups. See footnotes 1,2,6 and 8 above for the reasons why the summation of current catches and possible increases does not accord with the estimated potential yield.

(1) Salmons

Pink, chum, sockeye and chinook salmons were once depleted mostly by overfishing but also due to a deterioration in the spawning rivers during the 1960's. All now appear to be recovering. The increase in stock abundance of pink salmon of USSR origin (in both odd and even year classes), is particularly remarkable in recent years (Figure 5). Several tens of thousands of tons of catch may be taken additionally from naturally grown stocks. The great success of the re-stocking project of chum salmon in Japan is also encouraging (Figure 6). The Japanese coastal catch of chum salmon has increased by about 70 000 t within 10 years since 1970 and still shows indications of a further increase. The chum salmon originating from the USSR have remained at a low level in recent years (Figure 5). However, an increase in abundance and catch is expected in the near future as a result of a re-stocking project that was recently initiated in the USSR spawning rivers in collaboration with Japan. The total salmon catch could therefore be about 300-350 000 t, i.e. about 100 000 t more than the current catch, on a conservative basis (Table 14).

(2) Demersal fish

Almost all the conventional demersal stocks have been heavily fished and the exploitable fishing grounds in the Northwest Pacific have already been fished entirely by trawl and other bottom fishing gears (Section 7.2.10). The only exceptional stocks are Atka mackerel in the northern region (Figure 10) and sandlances around Japan to the East China Sea (Figure 11). These appear to have been only moderately exploited, and several tens or even hundreds of thousands of tons increase in the catch might be achieved with increased effort.

The many demersal stocks of commercial value in the Yellow Sea and East China Sea have seriously declined due to overfishing (Section 7.2.8, Figures 15, 16). The abundances of these stocks have declined during the 1960's to 1/5th-1/10th of their previous levels and each has remained at a relatively very low level in recent years. Implementation of appropriate regulatory measures is urgently needed. An assessment of the coastal fishing for the fry and juveniles of these species by stownet, dragnet and other gears is particularly urgently needed. A reduction in the total fishing effort, particularly in coastal waters appears to be essential. A mesh size regulation for both the coastal and offshore fishing also appears to be necessary. Many theoretical studies have predicted that far greater catches would be achieved within a few years if appropriate measures were effectively enforced. The author has reservations about the practicality of this for the time being considering the difficulties of implementing regulatory measures, even though several hundreds of thousands of tons increase in catch is expected in theory.

Stocks of Pacific ocean perch and other rockfishes have also been depleted by overfishing (Figure 12). However, recovery of these stocks may be slow even though regulatory measures have been enforced because of their particular biological characteristics (slow growth, older maturation, longer lifespan and lower fecundity).

Taken as a whole, a 100-200,000 t increase in catch is estimated in the future on a conservative basis and this would result in a potential harvest of about 6.5-7.0 million tons[1/] from the entire Northwest Pacific (Table 14). This may be influenced, firstly with improvements in the accuracy of the nominal statistics for China and the Korea D.P. Rep., secondly with changes in the stock abundance of prominent species, such as Alaska pollack and thirdly with the recovery of many stocks in the Yellow Sea and East China Sea.

(3) Coastal pelagic fish

The coastal pelagic stocks around Japan and further north appear to have been fully exploited. The total catch of the five major species (Japanese sardine, Japanese anchovy, Japanese chub mackerel, Japanese Jack mackerel and Pacific saury) has probably reached its maximum level, or even a level in excess of that in recent years (Figure 29). However, two important considerations affect the estimation of potential yield. First, it is not known what effect a recovery of the Pacific herring stocks would have if they recovered from their extremely low level in recent years (Figure 20) to their previous level during the 1910's-1920's with catches of 500-800,000 t annually (Appendix

1/ Differences from the nominal statistics could be about 800,000 t (Table 14). However, it is believed that a very large quantity of demersal fish has already been taken by the Chinese fishery along the entire coast. The total Chinese catch is estimated to be at least twice as great as the current nominal statistics (Table 10-(1)), making it about 1.2-1.3 million tons.

Table 19). If herring stocks recovered without affecting other southern stocks, the total potential could become considerably greater than the current catch. The second consideration concerns the recent increase in the Japanese sardine stocks around Japan (Figures 22, 29). The total sardine catch in the area reached about 3.5 million tons in 1981, which is an all time record and since then it has increased even further.[1/] An important fact is that huge catches have depended on just a few stocks around the Japanese coast and the stocks in the western Japan Sea along the Korean Peninsula to the Primorskiy coast are still at a very low level, and are contributing only 1.7 percent of the total catch (Figure 22, Appendix Table 13). If the western Japan Sea stocks were to increase like those in the 1930's (Ibid,), the total potential of all the sardine stocks together would be about 1 million tons or more greater than the current catch level.

From a conservative point of view, a production of about 2.5-3.0 million tons [2/] for the above mentioned five major species seems a reasonable estimate for the waters around Japan. Larger catches of 4.0-5.5 million tons are, therefore, probably only to be expected on a temporary basis, to be followed by declines as happened after the "Great Catch Period" of sardine during the early 1940's. There are two considerations therefore when dealing with the pelagic fish community in the region. The first is that a total potential yield of somewhere around 2.5-3.0 million tons, could be maintained by high primary productivity and favourable oceanographic conditions even if the dominant species changes from time to time. The second is that the total potential for all species combined may depend on which species happen to be dominant and what other species happen to be important.

The state of exploitation of the pelagic fish stocks in the southern region is not clear especially for those in the northwest South China Sea. However, it generally appears that many stocks of mackerel (spotted mackerel, short mackerel, island mackerel and Indian mackerel), sardines, anchovies and scads have not been fully exploited. An increase of at least 100-200,000 t in the catch of these species is possible.

Taken as a whole the potential yield of pelagic fish from the entire Northwest Pacific is estimated to be about 5.8-6.5 million tons (Table 14).

(4) Tunas and billfishes

All the stocks in this species group have already been fully exploited with the exception of longtail tuna and smaller tunas (bullet tuna, frigate tuna and kawakawa) in the southern region. The increase in the catch expected in the future is therefore probably no more than 20-30,000 t on a conservative basis. The total potential yield would then be around 280-380,000 t (Table 14).

(5) Cephalopods

Cephalopods constitute the only species group for which a future expansion is likely, although all the neritic cephalopod stocks around Japan have been fully exploited. Japanese flying squid have declined since the early 1970's (Figure 30) but it is difficult to estimate how the current level relates to the unexploited stock level due to the large fluctuations shown by this stock. The author considers that the potential yield of Japanese flying squid is about 300-400,000 t (Section 7.5.1(1)). Neritic squids in the southern region, especially those along the Chinese coast do not appear to have been intensively fished and probably around 50-60,000 t, could be additionally harvested in the future (Chikuni, 1983).

Oceanic squids in the northern region would have the next largest potential to that of Japanese flying squid with about 250-300,000 t of which about 150-180,000 thave been taken in recent years. The potential of oceanic squids in the southern region is, probably negligible mostly due to their lack of availability for commercial fishing.

Cuttlefishes generally appear to have been nearly fully exploited with the exception of some smaller-sized cuttlefishes in the south. Probably no more than an additional 10-20,000 t is to be expected on a conservative basis (Chikuni, 1983).

1/ Source: "Suisan Keizai Shinbun", a Japanese fisheries industrial newspaper.
2/ Annual catch taken during the first half of the 1970's (Figure 29, Appendix Table 19).

The octopus stocks in waters around Japan have been fully exploited but those in the southern region are virtually untouched. A considerable increase in the catch to about 50-60,000 t, could therefore be taken if suitable fishing methods were to be introduced into the southern region (Chikuni, 1983).

Overall, the total potential yield of cephalopods from the entire Northwest Pacific is estimated to be about 950-1,250,000 tons.1/ This represents a possible increase in total catch of about 250-350,000 t compared with the 700-900,000 t current catch (Table 14).

(6) Prawns and shrimps

All the prawn and shrimp stocks in the Northwest Pacific have been fully or partly overexploited. The current catches of about 400-600,000 t2/ are considered to represent a maximum potential yield and no greater catch is expected in the future (Table 14).

(7) Total potential harvest

It is assumed that the other components of the total marine catch3/ would have all been fully exploited and that the combined potential for these species is equivalent to the current catch of about 5,550,000 t. On this basis the total potential yield for all species combined from the Northwest Pacific is estimated to be about 19,780-21,630,000 t (Table 14) which may be the largest for any area in the world. The possible increase in the catch, of about 600-900,000 t, is large when compared to the current catches in many other areas (Table 13). However, at the same time, the rate of exploitation in the Northwest Pacific has already nearly reached its optimum with a catch of about 92-96 percent of the maximum potential yield.

It should be stressed again that there is considerable instability in having the total potential yield and actual catch dependent on a few major stocks. The estimated potential could therefore be subject to large temporary variations depending on the species composition and the environmental conditions.

9. MANAGEMENT OF RESOURCES AND FISHERIES

9.1 Measures Currently Employed

After the extension of national jurisdiction on fishing to 200 miles by the four nations in the area (Japan, Korea D.P. Rep., the U.S.A. and USSR), managerial responsibility for many major stocks in the northern part of the area has fallen onto each of the coastal countries.

9.1.1 National basis

The schemes of the resource management currently employed in each of the countries in the area are not clear except for Japan and the U.S.A.

(1) Japan

In Japan there has been a highly developed management scheme covering the entire fishery along the coast (Asada, 1973, Asada et al., 1983). Among a number of laws and acts enacted so far, the following three major laws cover the most important part of the management of fisheries and resources. These are: (1) the Fisheries Law, (2) the Fisheries Resources Conservation Law and (3) Fisheries Cooperative's Law. Each fishery is classed into one of three categories. These are: (1) Fishing Right Fishery, which comprises several exclusive fishing rights in the selected inshore to nearshore waters. These include setnet, bottom gillnet, beach-seine, seaweed culture, oyster/clam culture etc., (2) Licensed Fishery, which covers most of the fishing in coastal, offshore and distant waters such as trawling, purse-seining, longlining, angling, jigging etc. and (3) Others which include

1/ Potentials with increases (in brackets) in thousands of tons by species groups are: Japanese flying squid: 300-400 (50-100), neritic squids: 180-260 (50-60), oceanic squids: 250-300 (100-120), cuttlefishes: 110-170 (10-20), octopuses: 100-120 (50-60)

2/ Nominal catch of 300-350,000 t plus estimated Chinese and Korean D.P. Rep. catches of 100-250,000 t.

3/ Other fish, other crustacea, shellfish and others.

minor and miscellaneous fishing and for which the combined catch is usually less than 10 percent of the total. The Fishing Right Fishery is being governed by local government and the Licensed Fishery by both the central and local governments. The "Others" are free of legislation.

Application of these three laws has lead to firstly control of fishing effort in each of the first two kinds of fisheries, secondly various regulations for both the conservation of resources and for the prevention of conflicts between fishermen, and thirdly coordination and self-reliance in cooperative association with harmonious fishing and resources management.

For instance, Fishing Rights are generally granted to selected fisheries cooperatives. Fishing and aquaculture operations under these rights are well controlled by cooperation and coordination among the members of the granted cooperative. The fishing effort in the Fishing Right Fishery is regulated by the number of gears (aquaculture facilities) or the number of members in accordance with the capacity of the available waters and the potential harvest.

In the Licensed Fishery licences are given to individuals who belong to those fisheries cooperatives and fisheries enterprises which are members of a particular fisheries association. The fishing effort in each of the fisheries (fishing type and/or region specified) is regulated by a combination of (1) the total number of vessels to be licensed by size-category and (2) by the allowable engine power for each vessel size.

The total allowable fishing effort (number of rights in the Fishing Right Fishery and the number of vessels and their engine power in the Licensed Fishery) is determined by the central and local governments. There have been well organized authorized bodies for coordinating fisheries of three levels. These are: (1) The Regional Fisheries Coordinating Committee (for about 65 regions), (2) The Joint Regional Fisheries Coordinating Committee (for 3 specific sea-areas) and (3) The Central Fisheries Coordinating Council. The members of these bodies are selected from three different backgrounds. These are: (1) fishermen including aquaculture, (elected by fishermen), (2) men of learning and experience (nominated by the governor or the Prime Minister) and (3) representatives of public interests (nominated). All the management measures, including regulation of fishing effort, are taken after consultation and approval by the committee or council before enactment.

Fisheries cooperatives are also well organized on three levels; village or town to prefectural and national levels, and each acts in accordance with the above-mentioned different levels of governing body. The involvement of fishermen in management may have played an important role in the successful enforcement of a number of regulatory measures around Japan. These include various prohibitions on gears and methods, mesh size regulations, closure of seasons and grounds, etc. It should also be noted that many fisheries cooperatives are owners, or are closely or are deeply involved in the running of local fisheries wholesale markets. This has prevented illegal landings and has resulted in the better enforcement of regulations for species, seasons, grounds and sizes.

It has been distinctive in the Japanese scheme, in contrast to those employed in other advanced fishing nations of the world, that the catch quota system has scarcely been employed especially in connection with the catching of finfish. On rare occasions the application of a catch quota is limited to the collection of some red seaweeds or for lobsters and abalone etc. However, it appears that the Japanese system has worked out fairly successfully, judging by the fact that coastal catches have been maintained at the highest level in the world so far.

(2) Other countries

It has been said that in China a law for the conservation of fisheries resources was enacted several years ago and that several regulations have already been established by the government. However, details of the measures currently employed are not known.

The situation is the same for Korea Rep. and no information is available for the Korea D.P. Rep.

The only information available for the USSR on domestic regulations, is the prohibition of herring catching since around 1970 as described in the section on herring in this paper. All other domestic management measures and the state of enforcement are completely unknown.

Regulations for other countries in the area, including Hong Kong, Macau and Others, are not known either.

The U.S.A. which holds its own jurisdictional waters in the northern part of the region has established domestic management schemes for several fisheries. However, their fisheries have never entered into the Northwest Pacific area.

9.1.2 International basis

There have been several international arrangements for managing fisheries for a few parts of the Northwest Pacific as was described in section 6.2.2 of this paper.

Two Fisheries Conventions between Japan and the USSR deal with fishing in each others jurisdictional waters. They define various regulatory measures including quotas for the major species, total numbers of fishing vessels, fishing seasons and grounds for non-coastal fisheries. However, these are the results of political negotiation and it is difficult to assess how effectively the measures are linked with the entire management scheme in the region especially in USSR waters where no information on domestic measures is available.

The Japan-USSR Fisheries Cooperation Convention deals mostly with the Japanese salmon fishery on the high seas. Strict regulation has been imposed on the fishery.

The Japan-U.S.A. and Korea Rep.-U.S.A. agreements deal with the fishing by non-coastal countries in the U.S.A. waters in the area. Severe regulatory measures have been imposed on both fisheries. However, they are comparatively unimportant because of the small extent of U.S.A. waters in the area.

China and the Korea Rep. have not yet extended their jurisdiction on fishing, and, in return, Japan has not applied her extended jurisdiction to these countries. Joint regulatory zones have been established in parts of the Yellow Sea and East China Sea by China and Japan and by Japan and the Korea Rep. These are agreements for managing both the demersal and pelagic fish resources in the zones. This should lead towards better management in the future but is still incomplete from both the biological (partial coverage of shared stocks and no information on domestic measures in China and Korea Rep.) and practical points of view (separation of China and Korea Rep. and exclusion of Korea D.P. Rep.).

9.2 Future Requirements

9.2.1 Technical aspect

As discussed above, different species groups require different principles and practical methods of resource management. For example: (1) salmons are vulnerable to both heavy fishing and to any deterioration in their spawning and nursery areas. They do however possess a large potential for recovery if suitable management measures are applied, (2) demersal fish and prawns and shrimps are generally very vulnerable to heavy fishing, especially on the juveniles, (3) tunas and billfishes generally also appear to be vulnerable to heavy fishing and (4) coastal pelagic fish and cephalopods are, by contrast, less vulnerable to changes in fishing intensity but are sensitive to changes in environmental conditions. The management strategy should, therefore, take account of these differences, and the major lines to be employed would be as follows:

(1) Salmon

Salmon stocks, which were once depleted, show the benefit of re-stocking in recent years. For some stocks continuation and intensification of the re-stocking programme, should be made together with careful management of fishing by both the coastal and offshore fisheries.

(2) Demersal fish and prawns and shrimps

For a number of demersal fish stocks including prawns and shrimps which have become depleted and have not shown positive signs of recovery, a continuation of strict regulatory measures is most essential. This includes prohibition of catch in some cases, and mesh regulations, closure of grounds or closure of seasons etc. in others. Pacific ocean perch and rockfishes in the northern region, yellowfin sole and northern shrimp in the Okhotsk Sea, humpy shrimp in Anadyrskiy Bay, red seabream, and kuruma prawn in the waters around Japan would all be included in this category.

It appears that in the Yellow Sea to the East China Sea more comprehensive management measures need to be established for many demersal fish stocks which have been seriously depleted

and which are exploited by several nations either in coastal waters or in offshore waters or in a combination of both. The entire range of distribution and the entire life history of these stocks should be taken into account when deciding on management measures.

Monitoring of catches and stock assessments should be made continuously for demersal stocks for which a reasonably high level of stock abundance has been maintained so far. Prompt action should be taken if any signs of a decline are detected through monitoring. These considerations should be applied to Alaska pollack and Pacific cod in the Okhotsk Sea and in the northern region, and Atka mackerel, sandlances and several other demersal fish stocks around Japan.

(3) Coastal pelagic fish and cephalopod

For many of the coastal pelagic fish and cephalopod stocks the main causes of changes in abundance are natural, and beyond human control. There are almost no direct management measures to effectively control these stocks. Major concern should therefore be firstly for monitoring, and secondly for limiting catches when a stock happens to be declining. This may help to prevent the stock from reaching too low a level before the next phase of increase occurs. The catch level during such a period should be such as to maintain the spawning stock at a certain level and may differ greatly for different species. Many coastal pelagic fish such as Japanese sardine, Japanese chub mackerel, Japanese Jack mackerel, Pacific herring, Pacific saury and cephalopods (Japanese flying squid and other cephalopods) are included in this category.

In addition to the above-mentioned measures, the inclusion of a fisheries forecasting system in the management scheme should be extremely useful. In Japan a well developed fisheries forecasting system has been established and will be reported on by an FAO publication.

Japanese anchovy around Japan, other anchovies in the southern region and, possibly, sandlances in the entire area may be stocks for which no strict management measure is required. These stocks appear to be extremely insensitive to changes due to either fishing or natural causes.

(4) Tunas and billfishes

Tunas and billfishes that enter the Northwest Pacific need to be managed as in the other part of the world ocean. However, this cannot be achieved unless management measures extend beyond the Northwest Pacific area as discussed in the next sub-section.

9.2.2 Institutional arrangements

As discussed above, most of the action required for the management of the resources referred to in the previous sub-section, falls into the national jurisdictions of the various coastal countries. Success in managing the resources in the Northwest Pacific therefore basically depends on political factors in each country.

The management of stocks which are distributed in jurisdictional waters and are being exploited by both coastal and non-coastal countries, or exclusively by non-coastal countries, has been covered by several bilateral agreements, i.e. Japan-USSR, USSR-Japan and Korea, Rep.-Japan for the former and Japan-U.S.A. and Korea Rep.-U.S.A. for the latter. The results of scientific discussions associated with these agreements are generally confidential in nature. There may be no way for an outsider to learn the scientific details therefore. However, it is most desirable that data and information should be made available to outsiders in order to improve the understanding of marine science in the Northwest Pacific.

There is need from a technical point of view, as was discussed in the previous sub-section, for a multi-national organization to be established for the rational utilization of resources in the Yellow Sea and the East China Sea. Apart from Taiwan, Province of China, there have been four different nations involved in the exploitation of the resources in the region, namely China, Japan, Korea D.P. Rep. and Korea Rep. Many stocks, both demersal and pelagic, in the region are shared by these countries. Also, more importantly, many of the spawning and nursery grounds of demersal fish stocks are located along the Chinese coast and partly along the coasts of Korea D.P. Rep. and Korea Rep. where intensive fishing on juvenile fish of these stocks is believed to be being undertaken. The two existing bilateral agreements, China-Japan and Japan-Korea Rep., therefore cover only part of these stocks. It may be extremely difficult to establish such a multi-national organization in the immediate future, but intensive efforts to achieve this should be made in future.

A similar arrangement is required for the southwestern parts of the Japan Sea where several important stocks (e.g. Japanese flying squid and Pacific saury) are shared by Japan, Korea D.P. Rep., Korea Rep. and USSR.

The need for a common approach for managing tunas and billfishes in the Western Pacific should also be noted here. This should be on a global scale, extending beyond this particular area and may involve the solutions to a lot of problems. It may be extremely difficult to arrange for this in the immediate future. However, there is no doubt that those nations that are interested in exploiting these resources will have to move towards this goal sooner or later if they want to achieve a rational and well balanced exploitation of these resources. Intensification of activities in the Tuna Management Committee, IPFC may be one of the ways of achieving this for the time being.

10. FUTURE STUDY AND REQUIREMENTS

10.1 Research

10.1.1 Technical highlights

Several technical fields have been identified in the course of this review as requiring further research. They are summarized as follows:

(1) Environment

(a) Hydrography

1) Research on the causes of changes in the hydrographic system is of great importance because of the part these play in changes in stock abundance. For example, these include the effect of (1) the Oyashio and Okhotsk Gyre on Pacific herring and probably on Alaska pollack stocks, (2) the Kuroshio and Tsushima Warm Current on almost all the coastal pelagic fish including cephalopods around Japan.

2) Research on dynamic changes in the degree of convergence of these ocean currents is also needed because of their association with the changes in stock abundance and with various ecological features, including migratory routes, density, success or failure in spawning and feeding etc.

3) Although the waters around Japan are amongst the best surveyed and studied regions in the world, further detailed research is needed. The waters along the Chinese coast and the Korean Peninsula have, by contrast, not been well surveyed, and an intensification of research, including environmental research, is strongly recommended.

(b) Plankton

1) Information on the seasonal and annual changes in phytoplankton concentration appears to be insufficient for evaluating the secondary and higher levels of productivity in many waters, e.g. for Alaska pollack and Pacific herring stocks in the Okhotsk Sea and Japanese sardine around Japan.

2) Similarly, information on the carnivorous plankton and the causes of their changes in abundance is also needed. Therefore, it is not possible to determine the loss of eggs and larvae due to predation. Intensive surveys in association with spawning locations may be a practical approach to this problem.

(c) Primary production and benthos

1) Very little is known about these, and although it may be quite expensive to carry out further research this is still necessary.

2) It would be extremely useful to have reliable (or even probable) estimates of primary production, by sub-area for comparison with fish production.

(2) Resources

(a) Salmon

1) More information on feeding habits both qualitative and quantitative, is required for evaluating the effect on prey fish such as herring and saury.

2) Specific research on feeding habits and on the abundance of food organisms for salmon fry and juveniles in nearshore waters and adjacent to spawning rivers would provide important information in connection with the re-stocking programme.

(b) Demersal fish

Among the many subjects to be investigated, the following are, inter alia, highlighted.

1) Further detailed assessments of the Alaska pollack stock in the Okhotsk Sea and in other northern regions.

2) Studies of the inter-species relationship between Alaska pollack and Pacific herring in the Okhotsk Sea.

3) Research on the intra-species relationships between the pelagic and demersal forms of Alaska pollack in the northern region.

4) Species identifications of sandlances in the area, research on the biological features, studies of their inter-species relationships and an evaluation of their total biomass as prey species for other carnivorous fish species.

5) Further stock assessments of yellowfin sole in the Okhotsk Sea.

6) Stock assessments of red seabream around Japan and an appraisal of the re-stocking programme.

7) Investigation of the biological features of filefish.

8) Investigation of food habits (qualitative and quantitative) of carnivorous fish species to assess their predatory impact on prey species, such as sandlances, Japanese anchovy and shrimps.

9) An overall assessment of the demersal fish stocks in the Yellow Sea and East China Sea with special emphasis on an appraisal of coastal catches.

This is regarded as one of the most important requirements in the Northwest Pacific.

10) Intensification of research on the biology of demersal fish in the southern region.

11) Investigation of the life history of demersal fish on the seamounts in the Central Pacific.

(c) Coastal pelagic fish

The principal requirements are summarized as follows:

1) More research with a much more global and comprehensive point of view, on the dramatic changes in abundance and species composition of coastal pelagic fish around Japan.

This would be the biggest and most valuable subject in the Northwest Pacific.

2) An extension of these studies in connection with the total biological productivity of the region.

3) Studies of the inter-specific relationships between coastal fish species and other species in connection with competition and prey-predator relationships. For example, sardine versus mackerel, herring versus Alaska pollack, mackerel versus yellowtail and anchovy versus mackerel, etc.

4) Further investigation of the distribution, migratory habits, and food habits of Pacific saury.

5) In-depth studies of the changes in the reproductive potential of Japanese sardine and Japanese chub mackerel in connection with changes in larval mortality.

6) A study of the larval mortality of these two species in association with the carnivorous plankton ((1)-(b)-2)).

7) An appraisal of predatory loss specifically for Japanese anchovy, Japanese chub mackerel and Japanese Jack mackerel due to carnivorous fish and cephalopods.

8) Species identification and estimates of the degree of mixing of the two species of mackerels, Japanese chub mackerel and spotted mackerel, especially in the south.

9) Research on the biology of spotted chub mackerel in the southern region.

10) Research on the Carrangidae species in the south and a comparison with Japanese Jack mackerel.

11) A further assessment of Japanese amberjack (yellowtail) specifically to examine changes in both the abundance of the spawning stock and in the availability to coastal gears (large and small setnets) of adult fish.

12) Estimates of the loss, due to cannibalism, of the fry of Japanese yellowtail, and further appraisal of the "Mojako" catch for aquaculture.

13) Species identification of Spanish/king mackerels in the southern region and further research on them.

14) Further research on the biology of many other pelagic fish species in the southern region.

(d) Tunas and billfishes

Although investigations should not be confined to the Northwest Pacific area, important points covering the entire distribution range of the fish are summarized as follows:

1) Improved assessments for all species

Further research and a study of the important biological features of each species (population structure, migratory pattern, spawning, growth etc.) and of the fisheries is required. The following are *inter alia* of importance.

2) Changes in habitat and behaviour in relation to growth, especially for skipjack and yellowfin tunas.

3c) An analysis of the relationships between yellowfin and skipjack tunas caught by surface gear, and those caught by longlines in deeper water.

4) An appraisal of the catches of yellowfin and skipjack tunas taken by the recently developed fisheries in the western and southern Pacific Ocean, and especially of the catches of younger fish in and near the spawning and nursery grounds.

5) An analysis of the feeding habits of juvenile and adult fish to assess the predatory effect on other species.

6) An investigation of the losses due to cannibalism during the early life stage, for all species but especially for skipjack and yellowfin tunas.

7) Research, including exploratory fishing, on smaller tunas, bullet and frigate tunas and kawakawa, in the southern part of the Northwest Pacific.

(e) Cephalopods

1) Assessments of Japanese flying squid around Japan and of Japanese spineless cuttlefish in the Yellow Sea and East China Sea.

Further research is particularly needed in connection with the magnitude of spawning, and the causes of mortality during the early life stage since this may be a major cause of changes in stock abundance.

2) Further research on oceanic squids in the northern region.

3) An estimate of predatory loss, especially for Japanese flying squid due to tunas and billfishes.

4) An intensive survey, including exploratory fishing, of cephalopod resources in the southern region.

5) An appraisal of the re-stocking programme for common octopus in Japan.

This may be relatively unimportant in terms of catches but should provide valuable information from an ecological and technological point of view.

(f) Prawns and shrimps

Requirements for this species group are fewer and comparatively unimportant, except in the case of fleshy prawn in the Yellow Sea, humpy shrimp in Anadyrskiy Bay, northern shrimp in the Okhotsk Sea and kuruma prawn around Japan. Most other stocks appear to have been fairly stable with a high level of production. Particular points are summarized as follows:

1) An assessment of the fleshy prawn stock in the Yellow Sea including the Po-Hai Sea and Korea Bay.

2) Monitoring the recovery of humpy and northern shrimps in the northern region.

3) An assessment of kuruma prawn stocks around Japan and an appraisal of the re-stocking programme being employed in Japan. As in the case of octopus, this may be unimportant as far as catches are concerned, but the information should be valuable from an ecological and technological point of view.

4) An appraisal of the loss of shrimps due to predation by demersal fish, or an assessment of the importance of shrimp as food for demersal fish.

5) Species identification and research on pelagic shrimps along the Chinese coast and along the Korean Peninsula.

6) Research on the other shrimp resources in the southern region.

10.1.2 International collaboration

As discussed in the previous section, management of most of the resources falls into a number of national jurisdictions, so that the responsibility for research also falls within the same framework. The level of technical competence and the practical capacity of research vary greatly between countries in the Northwest Pacific. It is to be hoped however that all of the institutions concerned will make every effort to promote marine science, in order to achieve better assessments and management of the resources in the area.

In particular, the establishment of a firm basis for international collaboration is necesary for several stocks, and especially for shared stocks. The regions where such requirements exist are the southern part of the Okhotsk Sea including the adjacent Pacific Ocean, the northern and southwestern parts of the Japan Sea, the Yellow Sea and East China Sea and the waters around Hong Kong. Unfortunately, no such arrangement have been made so far. International collaboration made so far has been very limited and has only been done on a purely academic or political basis.

Collaboration through a multi-national arrangement is particularly required for the southwestern Japan Sea and the Yellow Sea to East China Sea for the reasons mentioned in section 9.2.2 and because of the biological characteristics described in the earlier part of this section.

A much wider collaboration is also required in the Western Pacific for research on tunas and billfishes, for which only a limited amount of work has been performed so far.

10.2 Statistics

As described in section 6.1 in this paper, the availability of fisheries statistics varies considerably from country to country. An improvement is essential in future, and details of what is required are given below.

10.2.1 Catch data

(1) Japan

Nominal statistics, with the aid of national yearbooks on fisheries statistics, are generally satisfactory regarding accuracy and breakdown into species/groups and gear (type of fishery). However, it is rather difficult to separate catches according to sub-areas (seas) and information is lacking for a few biologically important species (e.g. filefish).

(2) Korea Rep.

Data on species and gears in the national yearbooks of fishery statistics are second only to that provided by Japan. Information is conveniently compiled to distinguish catches according to two bordering Seas. However, species identification appears to be incomplete and classification is not consistent with international standards.

(3) USSR

There is a fair amount of information on species breakdown but it is incomplete for several species groups, e.g. flatfish. It is extremly difficult to break down catches according to Seas. No information is available on catch by gear-type. No national publication on statistics is available.

(4) China

Species breakdown is seriously incomplete. Separation of the catch into north (Yellow Sea and East China Sea) and south (South China Sea) is impossible. No information is available on the catch by gear-type. National yearbooks of fisheries statistics are not available.

(5) Hong Kong

Only nominal catch statistics by species are available.

(6) Macau

Only the total annual catches of marine fish and marine crustaceans are available.

(7) Korea D.P. Rep.

Nothing is available. FAO has estimated an annual total marine fish catch based on only fragmentary information.

10.2.2 Effort data

There have been fairly well documented data on effort (days operated or number of cruises) and the magnitude of fisheries (number of vessels by gear-type and size category and the numbers of enterprises) in the national yearbooks on fisheries statistics of Japan and Korea Rep. More detailed effort data for specific fisheries has been collected and processed for internal use and assessment purposes in these two countries.

Almost no information is available on fishing effort for other countries. It is believed that these data have probably been collected and processed in each country for domestic purposes, but no information is available.

Details of effort data may not necessarily be published for common use. However, it is essential that effort data be made available to national institutes for assessment purposes. Also, global figures on the magnitudes of fisheries, which are compatible with those provided by Japan and Korea Rep. should be made available to the public.

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Appendix Table 1

Salmon catches by species caught by the USSR coastal fisheries during 1953-81.[a/]

('000 t)

Year	Species				
	Pink	Chum	Sockeye	Coho	Chinook
1953	142.3	34.0	?[b/]	?[b/]	?[b/]
54	46.2	52.6	?	?	?
55	88.3	65.7	?	?	?
56	72.4	77.8	?	?	?
57	106.7	32.4	?	?	?
58	36.9	29.4	1.3	2.7	0.7
59	47.5	38.4	4.0	3.9	1.0
1960	19.7	44.3	4.3	3.0	0.7
61	30.7	38.5	7.6	4.7	0.7
62	16.5	34.4	5.0	4.9	1.0
63	35.7	33.6	3.4	7.4	1.0
64	14.7	26.5	3.1	1.2	1.4
65	48.0	32.8	4.5	3.3	1.2
66	21.3	30.3	3.9	3.2	1.0
67	51.1	25.5	3.2	3.7	0.9
68	16.6	16.2	2.4	3.3	0.8
69	63.5	8.4	1.7	3.4	1.2
1970	17.5	14.6	4.7	4.5	1.4
71	61.1	12.6	2.4	4.4	2.0
72	20.8	7.4	1.1	1.9	2.2
73	65.0	5.6	1.7	2.2	2.2
74	32.1	9.2	1.0	3.9	1.8
75	88.4	7.7	1.4	3.3	2.2
76	53.7	10.0	1.2	3.5	2.0
77	107.5	14.7	1.9	4.0	3.1
78	53.4	16.7	3.4	2.4	2.9
79	97.9	23.2	2.9	4.1	2.4
1980	77.3	14.6	3.9	2.5	1.1
81	79.8	12.9	3.8	3.6	1.4

a/ Source: FAO Statistical Yearbooks.
b/ Information not available for these species during 1953-57.

Appendix Table 2

Catch of chum salmon caught by the Japanese fishery total and the catches by setnet and salmon setnet fisheries during 1953-81.

Year	Total[a/] catch ('000 t)	Catch by[b/] all setnet fishery ('000 t)	Salmon setnet fishery[b/]		
			Number of setnet	Catch ('000 t)	Catch/net (t)
1953	21.7	6.1	?[c/]	5.7	–
54	51.2	8.3	?	7.2	–
55	106.7	5.7	?	5.0	–
56	80.0	4.6	?	3.8	–
57	86.1	7.9	476	6.3	13.2
58	107.3	7.6	450	5.6	12.4
59	79.8	4.9	395	3.3	8.5
1960	87.7	5.0	343	3.6	10.4
61	82.3	9.2	320	7.4	23.3
62	79.0	10.0	311	7.6	24.5
63	75.4	11.1	336	8.6	25.6
64	49.9	11.7	353	10.0	28.4
65	46.2	14.5	359	11.7	32.7
66	58.0	12.2	360	10.2	28.4
67	77.6	14.9	357	11.8	33.2
68	67.3	8.2	395	6.3	15.9
69	40.3	13.7	430	10.7	25.0
1970	54.5	18.1	409	14.8	36.3
71	59.9	27.4	408	20.9	51.3
72	64.5	23.5	420	18.0	42.8
73	60.6	30.7	478	25.3	53.0
74	77.5	36.8	518	32.0	61.7
75	92.9	54.3	503	46.9	93.3
76	74.8	33.8	597	27.7	46.4
77	68.4	41.8	664	33.2	50.0
78	70.1	50.0	674	40.4	59.9
79	95.3	73.5	726	58.9	81.1
1980	87.7	65.3	722	46.4	64.3
81	112.4	89.3	749	63.8	85.2

a/ Source: FAO Statistical Yearbooks, catch by all the fisheries including the coastal, offshore and high-sea salmon fisheries.

b/ Source: Japanese Yearbooks of Fisheries Statistics, estimated by the author from the combined catch of chum and pink salmons with a ratio of 0.9. This may be slightly underestimated.

c/ No data.

Appendix Table 3

Catch of Alaska pollack by country[a/] in the Northwest Pacific[b/] during 1953-80.

('000 t)

Year	USSR[c/]	Japan[d/]	Korea Rep.[e/]	Total
1953	5	225	18	249
54	10	242	15	267
55	10	231	28	269
56	9	234	31	275
57	9	281	43	334
58	21	285	39	345
59	52	376	21	449
1960	109	380	17	506
61	98	353	14	465
62	97	453	28	578
63	128	531	23	682
64	136	684	21	841
65	324	476	27	826
66	420	524	21	965
67	468	677	18	1,162
68	541	924	29	1,493
69	555	1,133	10	1,697
1970	673	1,273	13	1,959
71	803	1,771	71	2,045
72	638	1,996	149	2,783
73	1,275	2,395	257	3,927
74	1,396	2,062	297	3,755
75	1,700	1,818	388	3,906
76	1,887	1,619	453	3,959
77	1,928	1,357	332	3,617
78	1,916	990	251	3,203
79	2,015	931	188	3,135
1980	2,071	971	152	3,193
81	2,138	903	90	3,131

a/ No information is available for the catch by Korea D.P. Rep.
b/ Fishing area includes the western Bering Sea, Okhotsk Sea, Japan Sea and the northwestern Pacific Ocean along the coast of Kamchatka to northern Japan.
c/ Taken mostly from the Okhotsk Sea.
d/ Mostly from the Okhotsk Sea and Pacific Ocean along the coast of northern Japan and partly from the western Bering Sea and Japan Sea.
e/ Mostly from the Japan Sea and partly from waters around southern Kamchatka. See text.

Appendix Table 4

Catalog of Pacific cod by country[a/] during 1953-81.

('000 t)

Year	Japan	USSR	Korea Rep.	Total
1953	28	13	2	43
54	26	20	2	48
55	40	17	3	59
56	35	22	4	61
57	66	18	2	86
58	60	12	2	74
59	66	10	3	79
1960	68	12	2	82
61	68	10	2	79
62	76	9	1	87
63	90	7	1	98
64	95	5	2	102
65	72	6	2	81
66	65	6	2	73
67	62	10	2	73
68	62	14	2	78
69	60	28	3	91
1970	59	12	3	74
71	67	30	3	99
72	58	19	1	78
73	84	26	2	111
74	72	19	3	94
75	62	26	7	96
76	58	1	1	60
77	58	11	2	71
78	53	10	2	65
79	55	10	2	67
1980	46	21	1	68
81	49	41	4	93

a/ No information is available for the catch by Korea D.P. Rep.

Appendix Table 5

Catch of Atka mackerel by country[a] during 1953-81.

('000 t)

Year	Japan[b]	USSR[c]	Korea Rep.[d]	Total
1953	159	-		159
54	114	-		114
55	114	-		114
56	121	-		121
57	106	-		106
58	48			48
59	100			100
1960	116			116
61	185	?[e]		185
62	122			122
63	150			150
64	205	7		212
65	107	7	?[e]	115
66	106	5		111
67	82	4		86
68	87	24		111
69	103	15		118
1970	147	16		162
71	147	21		168
72	181	30		211
73	115	22		137
74	143	44	10	197
75	115	92	13	220
76	229	64	2	296
77	235	44	12	291
78	134	34	11	179
79	117	33	8	158
1980	114	8	5	127
81	116	4	3	123

a/ Data from the Korea D.P. Rep. is not available.
b/ Mostly taken around Hokkaido.
c/ Supposedly from the southern Okhotsk Sea.
d/ Mostly from the Japan Sea along the east coast of the Korean peninsula.
e/ Catch data not available, probably negligible.

Appendix Table 6

Catch of sandlance[a/] by country[b/] during 1953-81.

('000 t)

Year	Japan[c/]	Korea Rep.[d/]
1953	66	?[e/]
54	43	
55	59	
56	78	
57	87	
58	98	
59	69	
1960	79	
61	108	
62	70	7
63	84	2
64	55	6
65	111	1
66	71	2
67	103	4
68	151	4
69	107	6
1970	227	7
71	272	0
72	195	2
73	194	5
74	299	4
75	275	3
76	224	3
77	137	5
78	103	5
79	111	8
1980	201	5
81	162	11

a/ Four species are probably involved but the taxomatic status of these has not yet been confirmed. See text.

b/ The USSR fishery catches sandlance occasionally, probably from the southern Okhotsk Sea. Information on Chinese and Korea D.P. Rep. fisheries is not available.

c/ Mostly from the central to northern Pacific coasts including the Seto Inland Sea. Catches from the south and west Pacific coasts and the Japan Sea coasts are very small.

d/ Mostly from the Japan Sea coast.

e/ Data not available.

Appendix Table 7

Catch of Pacific ocean perch in the northwest Pacific[a/] and the waters along the Aleutian Islands[b/] during 1960-81.

('000 t)

Year	Northwest[a/] Pacific	Aleutian[b/] Islands
1960	?	-
61	?	-
62	?	0.2
63	?	20.8
64	?	90.3
65	43.5	109.1
66	36.1	85.9
67	25.7	55.9
68	31.0	44.9
69	19.5	38.8
1970	12.4	66.9
71	17.3	21.8
72	6.0	33.2
73	15.9	11.8
74	28.5	22.4
75	22.9	16.6
76	15.5	14.0
77	8.8	5.9
78	12.2	5.3
79	14.8	5.5
1980	14.9	3.3
81	12.4	3.5

a/ Source: FAO Statistical Yearbooks. FAO Fishing Area 61 which is west of 175°W.

b/ The area includes the entire Aleutian Islands beyond 175°W.

Source: (1) 1960-72; Chikuni (1975).

(2) 1973-76; Forrester *et al.*, (1983).

(3) 1977-81; various, estimated by the author based on the reported catch quota for each year.

Appendix Table 8

Catch of yellowfin sole[a/] by country[b/] during 1953-81.[c/]

('000 t)

Year	USSR	Japan	Total
1953	22	-	22
1954	14	-	14
1955	44	-	44
1956	70	-	70
1957	65	8	73
1958	105	8	113
1959	84	9	93
1960	64	12	76
1961	47	11	58
1962	41	15	56
1963	23	22	45
1964	23	22	45
1965	27	21	48
1966	27	21	48
1967	25	13	38
1968	21	-	21
1969	19	7	26
1970	14	13	27
1971	20	13	33
1972	22	6	28
1973	20	11	31
1974	12	12	22
1975	13	12	25
1976	12	6	18
1977	18	3	21
1978	45	5	50
1979	22	3	25
1980	22	1	23
1981	23	1	24

a/ The catch has been taken nearly exclusively from the Okhotsk Sea.
b/ The catch by the USSR fishery includes the "Other flatfishes", 20-40 percent of the total. See text for details.
c/ Source: (1) Anon. (1974, 1976a) and FAO Statistical Yearbook.

Appendix Table 9

Catch of the other major demersal fish in the coastal waters around Japan during 1956-81.[a/]

('000 t)

Year	Flatfish	Sea breams	Sandfish	Hairtail	Lizard fishes	Croakers	Daggartooth pike-conger	Pacific butterfish	Nine species total
1956	99	27	17	4	9	3	4	0.6	164
57	102	29	13	4	10	7	3	1	169
58	108	29	14	5	9	3	3	3	174
59	103	31	22	5	9	4	2	2	178
1960	96	31	15	5	9	4	2	2	164
61	84	27	21	5	8	4	3	2	154
62	93	27	24	7	9	4	3	3	170
63	102	27	26	6	8	4	3	4	180
64	103	29	22	5	6	4	3	2	174
65	120	32	32	7	7	3	2	3	206
66	148	30	36	10	8	3	2	3	240
67	137	33	33	12	8	4	2	2	231
68	135	32	38	9	9	3	2	2	230
69	117	27	31	14	9	3	1	1	203
1970	121	26	31	14	6	4	2	0.6	205
71	127	24	32	16	6	5	1	0.6	212
72	125	25	29	21	6	5	1	0.2	212
73	147	23	31	19	7	6	2	0.3	235
74	135	23	34	21	7	7	2	0.2	229
75	140	23	35	21	7	7	3	0.2	236
76	144	24	23	21	8	8	2	0.2	230
77	133	24	15	13	9	10	2	0.3	206
78	132	25	13	16	10	8	3	0.3	207
79	123	24	10	18	11	7	3	0.0	196
1980	119	24	12	25	11	7	3	0.1	201
81	126	21	10	24	13	7	3	0.4	204

a/ Source: Japanese Yearbooks of Fisheries Statistics. See text for the species involved.

Appendix Table 10

Catch of demersal fish by major species and country in the Yellow Sea and East China Sea. The catch by Korea D.P. Rep. is not known.

(1) Chinese catch[a/] during 1970-81

('000 t)

Year	Large yellow croaker	Small yellow croaker	Largehead hairtail	Total[b/]
1970	159	30	392	581
71	144	34	430	607
72	149	21	496	665
73	138	32	564	734
74	197	?	577	775
75	140	?	484	624
76	124	?	434	557
77	91	?	393	484
78	94	?	387	481
79	83	36	437	556
1980	86	36	473	596
81	80	35	499	614

a/ The catch by Taiwan, Province of China, is not included due to the large difference in species breakdown. The catches include those from the northwestern South China Sea due to the difficulty in separating them from the region.

b/ Simple summation of the only three species which have been identified in the nominal catch statistics. The so-called "Total demersal fish catch" is believed to be greatly larger than these figures. See Appendix Table 10-(4) for filefish.

Appendix Table 10 Continued

(2) Japanese catch by offshore trawl fisheries[a] during 1956-81 [b]

('000 t)

Year	Total[c] catch	Flatfish	Yellow croaker	Black croaker	Lizard fish	Daggertooth pike-conger	Largehead hairtail	Red sea bream	Yellow sea bream	Sharks and skates	Composition of nine species in total catch (%)
1956	300	26	59	12	16	24	22	4	7	18	62
57	319	26	70	12	15	27	23	2	8	17	62
58	329	24	61	13	17	30	26	5	12	16	62
59	333	26	74	6	13	31	28	7	11	13	62
1960	342	26	88	3	14	30	32	3	5	13	63
61	352	24	70	4	12	31	36	2	6	12	56
62	308	24	57	3	12	28	27	1	4	11	55
63	326	25	63	4	10	30	31	3	4	11	56
64	278	20	43	2	15	26	39	4	3	10	56
65	300	19	72	3	16	27	41	1	3	7	63
66	308	19	66	2	16	31	35	2	4	7	59
67	316	16	56	1	17	25	56	1	4	7	58
68	304	18	45	1	14	23	50	1	4	6	53
69	283	18	42	2	8	25	50	0.2	4	6	54
1970	257	16	42	0.3	10	20	41	1	3	7	54
71	233	17	26	0.3	15	19	30	1	3	6	49
72	195	17	14	0.4	10	17	25	1	3	6	48
73	192	17	17	0.2	13	17	22	2	3	6	51
74	182	20	20	0.0	11	16	18	1	2	5	51
75	175	26	12	0.0	11	18	11	1	2	5	49
76	160	22	10	0.0	8	15	9	1	3	5	47
77	174	17	7	0.0	11	17	15	1	3	5	44
78	167	16	4	0.1	9	15	12	1	4	6	40
79	171	15	7	0.1	8	13	13	1	4	6	39
1980	170	17	4	0.1	11	13	13	1	4	6	40
81	160	16	4	0.1	11	13	11	0.4	4	5	41

a/ "Isei Sokobiki Gyogyo" comprised both otter and pair trawlers licensed to operate exclusively in the Yellow Sea and East China Sea.
b/ Source: Japanese Yearbooks of Fisheries Statistics.
c/ Excludes cephalopod and crustacea.

Appendix Table 10 Continued

(3) Korea Rep. catch with the average size of trawlers[a/] during 1965-81 [b/]

('000 t)

Year	Flatfish	Yellow croaker	Other croakers	Lizard fish	Daggertooth pike-conger	Largehead hairtail	Sea-breams	Sharks and skates	Total[c/]	Size of trawler	
										Hull[d/] (GT/vessel)	Engine[d/] (PS/vessel)
1965	16	40	7	0.1	2	38	2	14	117	60	131
66	16	45	13	0.2	3	45	2	11	135	?	?
67	21	36	24	0.1	3	49	3	15	150	74	178
68	23	45	12	0.1	4	19	4	15	122	78	196
69	22	30	17	0.2	3	48	2	16	137	81	213
1970	27	32	31	0.2	3	69	2	14	178	93	278
71	23	25	24	0.2	3	83	2	12	171	100	323
72	26	25	33	0.3	4	110	3	14	216	92	297
73	30	25	44	0.4	5	124	3	15	247	120	410
74	28	54	68	1	6	166	5	15	341	121	404
75	29	40	38	1	8	120	5	18	257	95	356
76	31	45	53	0.4	6	75	3	15	229	91	292
77	28	26	32	1	9	72	4	13	185	98	402
78	24	25	31	0.2	10	86	3	13	192	102	?
79	23	35	37	1	7	120	4	14	240	99	409
1980	24	49	46	1	5	120	4	13	262	102	418
81	32	34	52	1	7	147	5	16	293	101	439

a/ Pair trawlers, categorized as the "large two-boat trawl in adjacent waters" in Korea Rep., which accounts for the largest demersal fish catch among the fisheries involved.
b/ Source: Korean Yearbooks of Fisheries Statistics.
c/ Simple summation of the eight species, which must therefore be substantially smaller than the so-called "Total demersal fish catch". See Appendix Table 10-(4) for filefish.
d/ GT: gross tons; PS: horsepower.

Appendix Table 10 Continued

(4) Catch of filefish[a/] by China and Korea Rep. in the Yellow Sea and East China Sea with a supplementary catch record of a selected fishery in Japan[b/] during 1960-81

Year	China total	Korea Rep.[a/] total	Japan selected[b/]
	('000 t)	('000 t)	(t)
1960			0.7
61			0.8
62			0.7
63			0.3
64			0.3
65			1.5
66	?[c/]	? [c/]	2
67			2
68			12
69			160
1970			550
71			900
72		0.3	900
73		2	450
74		13	800
75		81	300
76		115	250
77	230	128	600
78	310	200	550
79	105	230	450
1980	161	229	550
81	209	188	?

a/ Navodon modestus (Günther). Although a different species name is given to the nominal catch statistics from Korea Rep., it is believed that the majority of the catch would be N. modestus. See text for details.

b/ A setnet fishery located at the central Pacific coast of Japan (Kobata, 1981).

Appendix Table 11

Catch of Pacific herring by country[a/] and region during 1953-81.

('000 t)

Year	Japan		USSR				China[g/]	Korea[b/] Rep. (Japan Sea and Yellow Sea)
	Total[b/]	Setnet[c/] fishery (along northern Japan)	Total[b/]	Okhotsk[d/] Sea	Other regions[e/] Total[f/]	Other regions[e/] Korfa[g/] Karaginsk	Yellow Sea	
1953	275	155	171	74	97			0
54	132	75	125	54	71			0
55	47	16	136	54	82			0
56	36	6	154	80	74	?	?	0
57	47	4	297	168	128			0
58	38	1	333	244	89			0
59	17	4	235	127	108			0
1960	15	4	193	49	144	128		0
61	98	7	273	48	224	196		0
62	31	3	321	127	194	159		0
63	46	1	393	217	177	117		0
64	57	2	413	280	133	107		0
65	50	1	320	251	69	70		0
66	46	3	321	199	122	116		0
67	61	7	339	277	62	54		0
68	31	0	416	402	18	18		1
69	51	1	433	393	40	–[h/]		1
1970	73	0	351	320	31	–	2	1
71	126	0	282	260	22	–	31	7
72	46	0	270	250	20	–	182	7
73	78	0	323	298	25	–	121	5
74	68	0	285	251	34	–	72	0
75	63	0	314	271	43	–	58	2
76	60	0	192	20	172	–	55	0
77	17	1	253	–[h/]	253	–	18	4
78	6	0	58	–	58	–	22	1
79	6	1	73	–	73	–	39	0
1980	11	0	79	–	79	–	38	0
1981	10	0	86	–	86	–	35	0

a/ Catch by Korea D.P. Rep. is not known.
b/ Source: FAO Statistical Yearbooks. The Japanese catch includes those taken from the USSR fishing zone until 1977.
c/ Source: Japanese Yearbooks of Fisheries Statistics. The catch throughly depends on the East Sakhalin to Hokkaido Okhotsk stock and West Sakhalin to Hokkaido Japan Sea stocks.
d/ Source: Kobayashi *et al.* (1979). The catch depended mostly on the Gizhisk-Kamchatka and Okhotsk stocks.
e/ The region includes the western Bering Sea, the Pacific coast of Kamchatka to the Kuril Islands and the Japan Sea.
f/ Subtracted 4/ from 2/.
g/ Source: Morita (1982).
h/ Commercial fishing banned.

Appendix Table 12

Catch of Pacific saury by country[a] during 1953-81.

('000 t)

Year	Japan[b]	USSR[c]	Sub-total[d]	Korea Rep.[e]
1953	254	-	254	7
54	293	-	293	8
55	497	-	497	9
56	328	-	328	15
57	422	-	422	23
58	575		575	21
59	523		523	31
1960	287	?	287	15
61	474		474	29
62	483		483	39
63	385		385	13
64	211	27	238	25
65	231	42	273	32
66	242	45	287	39
67	220	48	268	28
68	140	51	191	30
69	63	51	114	30
1970	93	45	138	25
71	190	43	233	31
72	197	47	244	39
73	406	50	456	34
74	135	51	186	32
75	222	69	291	26
76	105	40	145	42
77	253	67	320	23
78	360	78	438	22
79	278	69	346	17
1980	187	39	226	12
81	160	32	192	11

a/ Catch by Korea D.P. Rep. is not known.
b/ Majority of the catch has been taken from the Northwest Pacific stocks and the catch from the Japan Sea stock has been negligibly small.
c/ Probably taken mostly from the Northwest Pacific stock and partly from the Japan Sea stock.
d/ The figure may give the approximate level of the catch from the Northwest Pacific stock.
e/ Principally depends on the Japan Sea stock.

Appendix Table 13

Historical catch records of Japanese sardine by region and Japanese anchovy around Japan during 1910-81.[a]

('000 t)

Year	Around Japan			Western Japan Sea			Around[e] southern Sakhalin	Northwest[g] Pacific total	Japanese anchovy around Japan
	Japan[b]	USSR[c]	Total	Korea[d/e]	USSR[e/f]	Total			
1910	132	-	132	?	-	?	-	(132)	54
1911	128	-	128	?	-	?	-	(128)	59
12	146	-	146	?	-	?	-	(146)	105
13	172	-	172	24	-	24	-	196	97
14	210	-	210	39	-	39	-	249	107
15	231	-	231	71	-	71	-	302	95
16	235	-	235	NA	-	NA	-	(235)	122
17	370	-	370	67	-	67	-	437	88
18	252	-	252	NA	-	NA	-	(252)	84
19	264	-	264	74	-	74	-	338	122
1920	345	-	345	NA	-	NA	-	(345)	113
1921	294	-	294	72	-	72	-	366	90
22	314	-	314	67	-	67	0	381	89
23	406	-	406	74	-	74	0	480	100
24	423	-	423	71	-	71	1	495	94
25	488	-	488	99	-	99	0	587	92
26	429	-	429	146	-	146	0	575	99
27	517	-	517	271	-	271	1	789	91
28	573	-	573	307	-	307	0	880	103
29	675	-	675	390	-	390	0	1,065	92
1930	690	-	690	332	60	392	6	1,088	99
1931	954	-	954	398	90	488	2	1,444	81
32	1,097	-	1,097	314	90	404	8	1,509	60
33	1,481	-	1,481	272	90	362	9	1,852	44
34	1,385	-	1,385	628	100	728	10	2,123	82
35	1,307	-	1,307	835	120	955	18	2,280	71
36	1,586	-	1,586	1,025	110	1,135	26	2,747	42
37	1,145	-	1,145	1,423	140	1,563	49	2,757	63
38	989	-	989	1,017	100	1,117	0	2,106	95
39	999	-	999	1,238	110	1,348	3	2,346	92
1940	757	-	754	1,002	100	1,102	0	1,856	112
1941	1,089	-	1,089	667	20	687	0	1,776	110
42	685	-	685	70	0	70	-	755	176
43	461	-	461	-	-	-	-	461	126
44	250	-	250	-	-	-	-	250	121
45	155	-	155	-	-	-	-	155	105
46	241	-	241	-	-	-	-	241	118
47	240	-	240	-	-	-	-	240	109
48	247	-	247	-	-	-	-	247	128
49	329	-	329	-	-	-	-	329	144
1950	381	-	381	-	-	-	-	381	182

Appendix Table 13 Continued

('000 t)

Year	Around Japan			Western Japan Sea			Around[e/] southern Sakhalin	Northwest[g/] Pacific total	Japanese anchovy around Japan
	Japan[b/]	USSR[c/]	Total	Korea[d/e/]	USSR[e/f/]	Total			
1951	480	-	480	-	-	-	-	480	190
52	350	-	350	-	-	-	-	350	284
53	344	-	344	0	-	0	-	344	244
54	245	-	245	0	-	0	-	245	304
55	211	-	211	-	-	-	-	211	392
56	206	-	206	-	-	-	-	206	347
57	212	-	212	-	-	-	-	212	430
58	137	-	137	-	-	-	-	137	417
59	120	-	120	-	-	-	-	120	356
1960	78	-	78	-	-	-	-	78	349
1961	127	-	127	-	-	-	-	127	364
62	108	-	108	0	-	0	-	108	350
63	56	-	56	-	-	-	-	56	321
64	16	-	16	0	-	0	-	16	296
65	9	-	9	0	-	0	-	9	406
66	14	-	14	-	-	-	-	14	408
67	17	-	17	0	-	0	-	17	365
68	24	-	24	0	-	0	-	24	358
69	21	-	21	0	-	0	-	21	377
1970	17	-	17	0	-	0	-	17	366
1971	57	-	57	0	-	0	-	57	351
72	58	-	58	0	-	0	-	58	370
73	297	-	297	4	-	4	-	301	335
74	352	-	352	0	-	0	-	352	288
75	526	-	526	4	-	4	-	530	245
76	1,066	-	1,066	11	-	11	-	1,077	217
77	1,421	-	1,421	50	-	50	-	1,471	245
78	1,637	243	1,880	54	-	54	-	1,934	152
79	1,740	368	2,108	47	-	47	-	2,155	135
1980	2,198	359	2,557	38	-	38	-	2,595	151
1981	3,090	461	3,551	63	-	63	-	3,614	161

a/ Source: Kurita et al., 1956, Ishigaki et al., 1959, Ito, 1961, Kondo, 1980, Japanese and FAO Yearbooks of Fisheries Statistics.

b/ Includes the eastern Japan Sea and East China Sea along the Japanese coast.

c/ Mostly from the Pacific coast of Japan.

d/ Mostly from the east coast of the Korean Peninsula.

e/ Including a small amount of round herring and anchovy before 1942 which had been caught along the whole east coast of the Korean Peninsula when the nation was not divided into two countries.

f/ Along the Primorskiy coast of USSR.

g/ Figures in brackets are lower by about 20-70,000 t due to the lack of information on the Korean catch.

Appendix Table 14

Catch of Japanese anchovy by country and the changes in the fishing power of the anchovy fleet in the Korea Rep.

(1) Catch by size category and by country during 1953-81[a]

('000 t)

Year	Adult fish			"Shirasu"[b]
	Japan	Korea Rep.	Total	Japan
1953	244	12	255	20
54	304	16	320	23
55	392	18	409	28
56	347	29	376	29
57	430	35	465	21
58	417	38	455	23
59	356	37	393	29
1960	349	36	386	21
1961	367	40	407	24
62	350	47	396	26
63	321	32	353	19
64	296	36	332	38
65	406	57	463	33
66	408	66	474	35
67	365	79	444	35
68	358	63	421	42
69	377	115	492	32
1970	366	54	420	35
1971	351	67	418	41
72	370	104	474	51
73	335	95	431	58
74	288	173	461	39
75	245	175	421	47
76	217	126	343	60
77	245	141	386	42
78	152	183	336	41
79	135	162	296	55
1980	151	170	320	55
1981	161	184	345	53

a/ Catches by China and Korea D.P. Rep. are not known.
b/ In Japan, postlarvae with 20-30 mm body length up to juveniles with lengths of 35-50 mm.

Appendix Table 14 Continued

(2) Change in the fishing power of the anchovy dragnet fishery in Korea Rep. during 1965-80 a/

Year	Number of vessels			Fishing efficiency in mechanized vessels		
	Mechanized	Non mechanized	Total	Total anchovy catch ('000 t)	Engine power per vessel (PS)	Catch per vessel (t)
1965	413	713	1 126	17	38	42
66	?	?	?	?	?	?
67	386	705	1 091	21	39	55
68	391	719	1 111	21	39	64
69	472	679	1 151	55	31	116
1970	?	?	?	?	?	?
1971	330	424	754	26	50	79
72	441	527	968	46	41	104
73	480	347	827	53	53	110
74	477	266	743	69	40	145
75	535	297	832	96	37	179
76	571	51	622	67	59	117
77	732	59	791	79	61	107
78	740	20	760	114	80	154
79	831	2	833	109	73	131
1980	879	–	879	104	79	118
1981	776	–	776	99	93	128

a/ Source: Yearbooks of Fisheries Statistics, Korea Rep.

Appendix Table 15

Catch of mackerels[a] by major region and country during 1953-81.

('000 t)

Year	Around Japan				Western East China Sea[b]			Northwest Pacific Total
	Japan	Korea Rep.[c]	USSR[d]	Total	China	Others[e]	Total	
1953	235	21	-	256		6	6	262
54	297	27	-	324		5	5	329
55	244	19	-	263		8	8	271
56	266	14	-	280		10	10	290
57	275	13	-	288		9	9	297
58	268	6	-	274		9	9	283
59	295	2	-	297		10	10	307
1960	351	2	-	354	?	10	10	364
1961	338	2	-	340		9	9	349
62	409	4	-	413		9	9	422
63	465	5	-	470		12	12	482
64	496	2	-	498		17	17	515
65	669	7	-	676		19	19	695
66	624	2	-	626		15	15	641
67	688	3	6	677		10	10	687
68	1,015	10	15	1,040		21	21	1,061
69	1,011	42	15	1,068		24	24	1,092
1970	1,302	38	30	1,370	173	31	204	1,572
1971	1,253	61	62	1,376	37	25	62	1,435
72	1,188	79	126	1,393	78	18	96	1,489
73	1,134	74	195	1,398	93	10	103	1,504
74	1,330	81	244	1,655	114	10	124	1,772
75	1,317	70	168	1,555	84	4	88	1,644
76	978	107	212	1,297	79	4	83	1,380
77	1,353	113	149	1,615	135	8	143	1,779
78	1,626	100	226	1,952	282	5	287	2,239
79	1,491	120	194	1,805	205	6	211	2,016
1980	1,301	63	225	1,589	84	6	90	1,679
1981	908	108	249	1,266	73	6	80	1,346

a/ Mostly composed of Japanese chub (common) mackerel but the catch includes "Goma"-mackerel, Scomber tapeinocephalus due to the difficulty of separating them in the commercial catches. These usually account for less than 5 percent of the total catch around Japan.
b/ Includes the northern South China Sea along the Chinese coast.
c/ Mostly from the eastern East China Sea and partly from the Japan Sea.
d/ Mostly from the Pacific Ocean along the Japanese coast.
e/ Hong Kong and Taiwan, Province of China.

Appendix Table 16

Catch of Japanese Jack mackerel by country[a/]
and the Japanese catch by region during 1953-81.

('000 t)

Year	Catch by country[a/]				Japanese catch by region[b/]			
	Japan	Korea Rep.[c/]	USSR[d/]	Total	Northern Japan Sea	Southern Japan Sea	Eastern East China Sea	Pacific Ocean
1953	240	8	-	248	6	33	110	91
54	251	8	-	259	7	47	144	52
55	239	12	-	251	15	50	113	60
56	247	11	-	258	16	64	109	57
57	282	13	-	295	15	110	68	88
58	282	48	-	330	25	114	81	62
59	432	33	-	465	33	187	147	65
1960	552	25	-	577	38	248	202	63
1961	511	24	-	535	21	209	214	67
62	499	18	-	517	16	181	228	74
63	441	12	-	453	13	122	196	110
64	497	20	-	517	8	184	237	67
65	527	27	-	554	6	176	289	56
66	477	10	-	487	9	170	257	41
67	328	5	1	334	11	101	151	65
68	311	3	1	315	11	64	151	86
69	283	2	1	286	8	70	126	79
1970	216	1	6	223	6	49	93	68
1971	271	9	4	283	8	61	150	52
72	152	3	1	157	7	32	69	44
73	128	2	0	131	5	28	58	37
74	166	2	1	169	7	37	74	47
75	187	7	0	193	8	35	100	44
76	128	7	0	136	8	20	69	31
77	88	5	1	95	3	11	43	31
78	59	4	1	64	2	6	32	18
79	84	7	2	93	4	14	50	16
1980	56	1	-	57	4	8	29	15
1981	66	6	-	72	3	13	33	17

a/ Source: FAO Statistical Yearbooks, catches by China and Korea D.P. Rep. are not known.
b/ Source: Japanese Yearbooks of Fisheries Statistics.
c/ Taken from both the western Japan Sea and the eastern East China Sea.
d/ Mostly from the Pacific coast of Japan.

Appendix Table 17

Catch of yellowtail[a/] by country and major fishery in Japan during 1953-81 in comparison with the development of yellowtail aquaculture in Japan.

Year	Catch by country[b/]			Catch by major fishery[c/] in Japan					Aquaculture[c/] in Japan	
	Japan ('000 t)	Korea Rep. ('000 t)	Total ('000 t)	Large setnet ('000 t)	Small setnet ('000 t)	Hook and line ('000 t)	Setnet ('000 t)	CPUE[d/] large setnet ('000 number)	Production ('000 t)	Seedfish[e/] used (millions number)
1953	49	3	51	35	1	7	2	67	-	-
54	46	3	49	33	2	8	1	100	-	-
55	46	4	50	33	2	6	1	58	-	-
56	43	3	46	29	2	7	2	35	0	?
57	42	2	45	25	2	8	3	60	0	?
58	43	1	44	24	2	8	5	42	0	1
59	47	1	48	28	2	8	5	25	1	1
1960	43	1	44	20	2	10	4	22	1	3
1961	54	0	54	25	2	14	4	17	2	7
62	53	1	54	19	2	14	7	8	5	9
63	45	0	45	15	2	12	6	3.5	5	8
64	43	1	44	18	2	11	7	16	9	18
65	44	1	45	18	2	13	4	20	15	22
66	39	1	40	17	2	10	5	14	17	27
67	49	2	50	18	3	12	10	0.9	21	34
68	48	3	51	14	3	15	9	0.8	32	37
69	51	2	53	18	4	13	10	0.1	33	43
1970	55	2	57	16	4	18	9	2.5	43	51
1971	48	1	49	15	4	14	5	9	62	51
72	50	1	51	15	4	13	8	4.2	77	68
73	53	2	54	14	4	15	8	1.5	80	68
74	41	2	43	13	3	11	5	0.5	93	57
75	38	3	41	13	3	9	5	2.7	92	63
76	43	2	45	12	4	14	6	7	102	81
77	27	2	29	7	3	9	3	1.3	115	76
78	37	2	39	13	5	8	5	2.0	122	83
79	45	2	47	13	5	10	10	1.4	155	81
1980	42	2	44	10	5	9	9	4.7	149	75
1981	41	1	42	12	4	8	5	?	151	80

a/ Includes a small amount of Seriola spp. (S. aureovittata and S. purpurascenus).
b/ Source: FAO Statistical Yearbooks.
c/ Source: Japanese Yearbooks of Fisheries Statistics.
d/ Source: Kanagawa Prefecture (1981) six large selected setnets along the central Pacific coast, Kanagawa Prefecture.
e/ Seedfish are taken from the recruitment (fry: 2-15 cm body-length) of the same stock to be exploited by the fisheries.

Appendix Table 18

Catch by Japanese Spanish mackerel by country[a] during 1953-81.

('000 t)

Year	China[b]	Korea Rep.[c]	Japan[d]	Total
1953			2.9	
54			2.2	
55			3.1	
56			3.8	
57	?		3.3	
58			3.2	
59		?	2.8	?
1960			2.8	
1961			3.1	
62	3.0		3.4	
63	7.4		3.6	
64	15.9		(3.5)[e]	
65	28.3	5.6	(3.5)	37.4
66	30.2	7.5	(3.5)	41.2
67	18.9	7.5	(3.5)	29.9
68	28.1	5.1	(3.5)	36.7
69	38.3	3.3	3.7	45.3
1970	26.6	5.3	4.4	36.3
1971	34.3	6.6	3.2	44.1
72	32.8	8.7	3.9	45.4
73	36.5	6.8	3.6	46.9
74	39.2	10.7	2.6	52.5
75	33.5	5.2	4.0	42.7
76	28.2	5.3	4.8	38.3
77	38.2	6.7	5.8	50.7
78	34.5	10.0	6.9	51.4
79	42.4	12.1	6.1	60.4
1980	51.4	17.5	6.9	75.8
1981	48.1	13.9	6.9	68.9

a/ Catch by Korea D.P Rep. is not known.
b/ Source: FAO Statistical Yearbooks after 1972 and Wang (1982) before 1971.
c/ Source: FAO Statistical Yearbooks and Korean Yearbooks of Fisheries Statistics.
d/ Source: FAO Statistical Yearbooks and Japanese Yearbooks of Fisheries Statistics.
e/ Figures in brackets were estimated by the author.

Appendix Table 19

Historical catch record of major coastal pelagic fish species around Japan[a] during 1912-81.[b]

('000 t)

Year	Herring[c]	Sardine[d]	Anchovy[e]	Jack[d] Mackerel	Chub[d] Mackerel	Saury[d]	Total
1912	515	146	105	12	34	60	872
13	787	172	97	11	34	35	1,136
14	746	210	107	11	37	19	1,130
15	672	231	95	10	40	25	1,073
16	651	235	122	14	47	24	1,093
17	421	370	88	14	50	18	961
18	479	252	84	11	59	6	891
19	722	264	122	13	55	8	1,184
1920	751	345	113	13	50	14	1,286
1921	512	294	90	16	53	22	987
22	490	314	89	18	54	27	992
23	459	406	100	16	67	22	1,070
24	555	423	94	21	68	34	1,195
25	524	488	92	17	76	64	1,261
26	554	429	99	23	71	38	1,214
27	654	517	91	20	90	41	1,413
28	415	573	103	20	82	27	1,220
29	309	675	92	21	77	22	1,196
1930	329	690	99	20	72	21	1,231
1931	406	954	81	24	82	15	1,562
32	420	1,097	60	23	83	12	1,695
33	457	1,481	44	30	110	17	2,139
34	383	1,385	82	27	106	17	2,000
35	229	1,807	71	28	114	17	1,766
36	143	1,586	42	32	126	24	1,953
37	116	1,145	63	29	132	23	1,508
38	43	989	95	30	133	25	1,315
39	123	999	92	32	154	20	1,420
1940	185	754	112	49	122	27	1,249
1941	174	1,089	110	62	143	14	1,592
42	201	685	176	53	105	16	1,236
43	313	461	126	50	133	17	1,100
44	370	250	121	35	72	3	851
45	318	155	105	78	84	3	743
46	325	241	118	22	64	10	780
47	173	240	109	28	63	23	636
48	192	247	128	30	99	66	762
49	186	329	144	49	138	64	910
1950	173	381	182	72	188	126	1,122

Appendix Table 19 Continued

('000 t)

Year	Herring c/	Sardine d/	Anchovy e/	Jack d/ Mackerel	Chub d/ Mackerel	Saury d/	Total
1951	187	480	190	93	151	113	1,214
52	321	350	284	206	287	226	1,674
53	275	344	255	248	256	261	1,639
54	132	245	320	259	324	301	1,581
55	47	211	409	251	263	506	1,687
56	36	206	376	258	280	343	1,499
57	47	212	465	295	288	445	1,752
58	38	137	455	330	274	596	1,830
59	17	120	393	465	297	554	1,846
1960	15	78	386	577	354	302	1,712
1961	97	127	407	535	340	503	2,009
62	31	108	396	517	413	522	1,987
63	46	56	353	453	470	398	1,776
64	57	16	332	517	498	263	1,683
65	50	9	463	554	676	305	2,057
66	49	14	474	487	626	326	1,976
67	64	17	444	334	677	296	1,832
68	68	24	421	315	1,040	221	2,089
69	85	21	492	286	1,068	144	2,096
1970	97	17	420	223	1,370	163	2,290
1971	100	57	418	283	1,376	264	3,498
72	62	58	474	157	1,393	283	2,427
73	83	301	431	131	1,398	490	2,834
74	76	352	461	169	1,655	218	2,931
75	67	530	421	193	1,555	317	3,083
76	66	1,077	343	136	1,297	187	3,106
77	20	1,471	386	95	1,615	343	3,930
78	7	1,934	336	94	1,952	460	4,753
79	7	2,155	296	93	1,805	363	4,719
1980	12	2,595	320	57	1,589	238	4,811
1981	10	3,614	345	72	1,266	203	5,510

a/ Coastal and offshore waters including all the seas and oceans around Japan.

b/ Source: Japanese and Korean Yearbooks of Fisheries Statistics and FAO Statistical Yearbooks. Fishing nations involved are: Japan, Korea Rep. and USSR.

c/ Only for the Japanese fishery; no information is available for the USSR fishery.

d/ Includes the catch from the south coast and the entire east coast of the Korean Peninsula and Primoskij coasts of USSR for the period before World War II. The catch by the Korea Rep. fisheries along the Korean Peninsula and that by the USSR fishery along the Pacific coast of Japan are included since 1953.

e/ Includes the catch by the Korea Rep. fishery along the southern Korean Peninsula since 1953.

Appendix Table 20

(1) Catch of Japanese flying squid by country during 1953-81 a/

('000 t)

Year	Japanese flying squid a/		
	Japan	Korea Rep.	Total
1953	420		
54	399		
55	383		
56	291		
57	364		
58	354		
59	481	?	?
1960	481		
1961	384		
62	537		
63	591		
64	238		
65	397	68	465
66	383	75	458
67	477	39	516
68	668	85	753
69	478	60	538
1970	412	72	484
1971	364	38	402
72	465	53	518
73	334	44	378
74	310	31	341
75	358	40	399
76	281	45	326
77	208	18	226
78	216	18	234
79	213	26	239
1980	330	48	379
1981	166	62	228

a/ Source: FAO Statistical Yearbooks. Catch by Korea D.P. Rep. is not known.

Appendix Table 20 Continued

(2) Catch of the "Other squid"a/ by major fishing country during 1966-81b/ together with information on recent catches of oceanic squid in the northern region c/

('000 t)

Year	Other squid b/					Oceanic squid d/		
	Total	Major fishing country				Neon e/ flying squid		Boreal f/ clubhook squid
		Japan	Taiwan, China	USSR	(sub-total)	Japan	Taiwan, China	Japan
1966	61	54	3	3	(60)	-	-	-
67	71	60	3	7	(70)	-	-	-
68	59	53	3	3	(59)	-	-	-
69	69	55	3	11	(69)	-	-	-
1970	69	57	8	1	(66)	-	-	-
1971	85	66	5	11	(82)	?	-	2.2
72	97	75	10	8	(93)	?	-	0.8
73	114	82	23	6	(111)	?	-	0.1
74	104	79	13	9	(101)	17	-	5.1
75	137	110	19	9	(138)	42	-	-
76	194	152	23	8	(183)	85	-	2.2
77	247	203	17	19	(239)	125	0.8	0.1
78	315	224	16	8	(248)	151	2.1	0.1
79	361	204	30	31	(265)	124	3.4	0.1
1980	378	237	26	26	(289)	188	?	?
1981	338	255	26	23	(304)	?	?	?

a/ "Squids NEI" in FAO Statistical Yearbook.
b/ Includes the catch of oceanic squid. Source: FAO Statistical Yearbook.
c/ East of northern Japan (35°N) to the southern Kuril Islands (45°N).
d/ Source: Murata et al., (1976, 1980, 1982), Okutani et al., (1983), Tung (1981).
e/ *Ommastrephes bartrami*.
f/ *Onychoteuthis borealijaponica*.

Appendix Table 21

Catch of fleshy prawn by country[a/] during 1970-81.

('000 t)

Year	China[2/]	Korea Rep. [2/]	Japan[3/]	Total
1970	14.4	0.5	1.6	16.5
1971	13.2	0.3	1.0	14.5
1972	11.9	0.8	2.2	14.9
1973	32.6	3.9	10.5	47.0
1974	39.9	3.0	12.3	55.3
1975	29.1	5.9	4.5	39.6
1976	10.0	0.9	3.0	13.8
1977	25.1	2.1	4.2	31.3
1978	38.4	1.1	2.6	42.1
1979	33.0	1.3	2.9	37.2
1980	33.6	0.8	?	?
1981	37.5	0.5	?	?

a/ Catch by Korea D.P. Rep. is not known.
b/ Source: FAO Statistical Yearbooks.
c/ Source: Shojima et al., (1982), catch by the Japanese offshore trawl fishery ("Isei-Sokobiki Gyogyo").

Appendix Table 22

Catch of kuruma prawn by country and aquaculture production in Japan during 1956-81.

('000 t)

	Catch		Aquaculture		Catch		Aquaculture
Year	Japan[1/]	Korea Rep.	Japan[3/]	Year	Japan[1/]	Korea Rep.	Japan[3/]
1956	2.39		?	1969	1.29	?	0.30
1957	2.15		?	1970	1.30	0.10	0.30
1958	2.91		?	1971	1.99	0.60	0.31
1959	2.76		0.10	1972	2.25	0.80	0.45
1960	2.99		0.07	1973	2.75	1.70	0.65
1961	3.77		0.09	1974	2.65	1.96	0.91
1962	2.85	?	0.13	1975	2.90	4.30	0.94
1963	2.92		0.18	1976	2.58	0.71	1.04
1964	3.03		0.15	1977	2.44	0.77	1.12
1965	2.92		0.20	1978	2.67	3.04	1.18
1966	2.27		0.28	1979	2.47	0.38	1.48
1967	2.03		0.31	1980	2.31	0.65	1.55
1968	1.57		0.31	1981	2.93	0.83	1.67

a/ Source: FAO Statistical Yearbooks and Japanese Yearbooks on Fisheries Statistics.
b/ Source: FAO Statistical Yearbooks.
c/ Source: Japanese Yearbooks on Fisheries Statistics.

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Appendix Table 21

Catch of fleshy prawn by country during 1970-81.

Appendix Table 22

Catch of kuruma prawn by country and aquaculture production in Japan during 1956-81.

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